117

NORTH CAROLINA ESTUARINE FINFISH MANAGEMENT PROGRAM

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TABLE OF CONTENTS

PROJECT I

ESTUARINE FISH STOCK ASSESSMENT

LONG HAUL SEINE AND POUND NET SURVEYS

by

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Abstract

Long haul seine and pound net fisheries were sampled for species composition, seasonality, age and size structure from October 1980 through July 1981 in southwestern Pamlico Sound, Core Sound and their tributaries. Twenty-nine long haul seine samples, yielding 46 species, were taken. Spot, Atlantic croaker, Atlantic menhaden, pinfish, and weakfish composed 95% (by number) of the total samples. Spot and croaker composed 69.9% by weight. This fishery was mainly a sciaenid fishery of which young-of-the-year and yearling spot and croaker dominated the marketable catch. Samples from the Core Sound pound net fishery were dominated by *Paralichthys* flounders (94.3% by weight) of which *P. lethostigma* was the most abundant (87.7% by number and 94.7% by weight). Southern flounder were primarily one and two years old.

INTRODUCTION

North Carolina contains the largest sounds (semi-enclosed estuarine water bodies) of any single state on the United States east or gulf coasts. These estuaries and their tributaries function as major nursery areas for the young of commercially important fishes and invertebrates as well as providing habitat for adults. While inshore waters south of Morehead City are productive, sounds to the north support most of the commercial fishing activities (Roelofs 1953). Pamlico Sound (Figure 1) is the largest of the inshore water bodies with an estimated total drainage area (including large rivers) of 5,180,000 ha (Roelofs and Bumpus 1953) and is generally the major contributor to commercial fishing activities. Hygrographic and some physiographic information has been summarized by Roelofs and Bumpus (1953), Hobbie (1970), Schwartz and Chestnut (1973) and Williams et al. (1973).

One of the earliest accounts of the North Carolina fishing industry (Earll 1887) reported that finfish (exluding anadromous species) landed in 1880 totaled 2,307,878 kg (5,088,000 lb) and consisted of bluefish (*Pomatomus saltatrix*), mullet (*Mugil spp.*) spotted seatrout (*Cynoscion nebulosus*), weakfish, (*Cynoscion regalis*). By 1980 preliminary landings for these species had risen to 12,779,905 kg (28,174,867 lb) and total finfish landings (excluding anadromous fishes) were 135,924,015 kg (299,722,193 lb) including at least 39 species (Street 1981; K. B. West pers. comm.). These figures are not directly comparable since North Carolina fisheries have experienced a tremendous increase in effort and diversification since the mid-twentieth century. Presently, inshore finfish operations depend primarily on sciaenids (drums), southern flounder (*Paralichthys lethostigma*), and Atlantic menhaden (*Brevoortia tyrannus*).

The objectives of this project were to evaluate the species composition, seasonality, age and size structure of involved species, species growth, and localities of several of the major fisheries. These studies concentrated on the long haul seine and pound net fisheries, and covered the period from October 1980 through July 1981. This project was originally designed as a three year study but was prematurely curtailed because of a reduction in supporting federal funds. Unfortunately, for this reason some of the results are neither complete nor definitive.

METHODS

An attempt was made to sample monthly a minimum of four long haul and two pound net catches during the fishing seasons. Long haul fishing generally occurs from spring through fall. The flounder pound net fishery of Core Sound occurs in the fall. The sciaenid Pamlico Sound pound net fishery takes place during early summer through fall. At least one unculled randomly collected fish basket (36 kg) sample was obtained at the fishing location or occasionally at the fish dealer. All species in the basket were identified, counted, and measured to the nearest millimeter fork length (FL, for species with forked tails), total length (TL), or disk width (for skates and rays). Individual species group weights (to the nearest gram) were obtained separately for croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*), weakfish, southern flounder, and menhaden (*Brevoortia tyrannus*). All other species were weighed together. Only southern flounder, summer flounder (*Paralichthys dentatus*) and Gulf flounder (*P. albigutta*) were weighed separately during Core Sound pound net sampling. Additional species seen in the catches but not appearing in our samples were noted.

Scales were collected each month from a representative size range of croaker, spot, and as time permitted, weakfish. Scales were taken from below the lateral line under the posterior tip of the pectoral fin. Scales were washed with water and read on a microfiche reader at 36 X magnification (spot) or 24 X magnification (croaker). Scale measurements were made on an axis from the focus to the center of the anterior field. Annuli were distinguished using a combination of circuli spacing, cutting over in the lateral field, and the distribution of marginal increments.

Since croaker and spot have extended spawning and a long growing season, aging is facilitated by assigning a birthdate when fish of a particular year-class are assigned to the next year class even though the annulus for that year may not have formed. January was the birthdate given to spot, which is possibly near the peak in spawning. October has been used for croaker birthdates (White and Chittenden 1977) and it is probably near maximum spawning on the Atlantic (Morse 1980); therefore; that month was used in this study as a birthdate. A direct proportion method of back-calculation with a correction factor (Lee method) was used in this study (Bagenal and Tesch 1978).

Since the project was curtailed early, weakfish scales were not analyzed. Otoliths were removed from southern flounder and analyzed as described by DeVries (1981a).

Aging Definitions

Age Class (age group): A group of fish with the same age in years. Due to extended spawning and growing season, especially in sciaenids, fish of a particular age class designation may actually be older or younger than the designation implies.

Young-of-the-Year Age class 0 fish that are less than one year old, generally having no marks on scales or otoliths.

Yearlings: Fish in age class 1 that are in their second year.

Age Class 2: Fish in the third year of life.

RESULTS

Long Haul Seine Fishery

Twenty-nine long haul catches were sampled from October 1980 through July 1981 in an area from middle Pamlico Sound south to Back Sound (Figure 1). The majority of the samples (13) came from Core Sound during October.

The sampling yielded 46 finfish species, 3 species of invertebrates, and one species of sea turtle (Table 1). Almost twice as many species were observed in October as other months (Table 1). This is due to a greater sampling effort for that month and the fact that, in general, inshore species diversity is at a maximum in North Carolina during the fall. The number of species was fairly stable from May through July.

Nearly 93% (by number) of the total was contributed by five species, spot, Atlantic croaker, Atlantic menhaden, pinfish, and weakfish (Table 1). All except the pinfish were commercially important, and croaker, spot, and weakfish were the desired marketable species of this fishery. The high ranking of pinfish was due to the large numbers encountered in October in Core Sound. Other fishing areas or months did not exhibit large pinfish catches. Spot, croaker, menhaden, and weakfish also were the major fishes in our samples by weight (Table 2), comprising at least 39.3%, 30.6%, 9.8%, and 8.5% of the total weight, respectively.

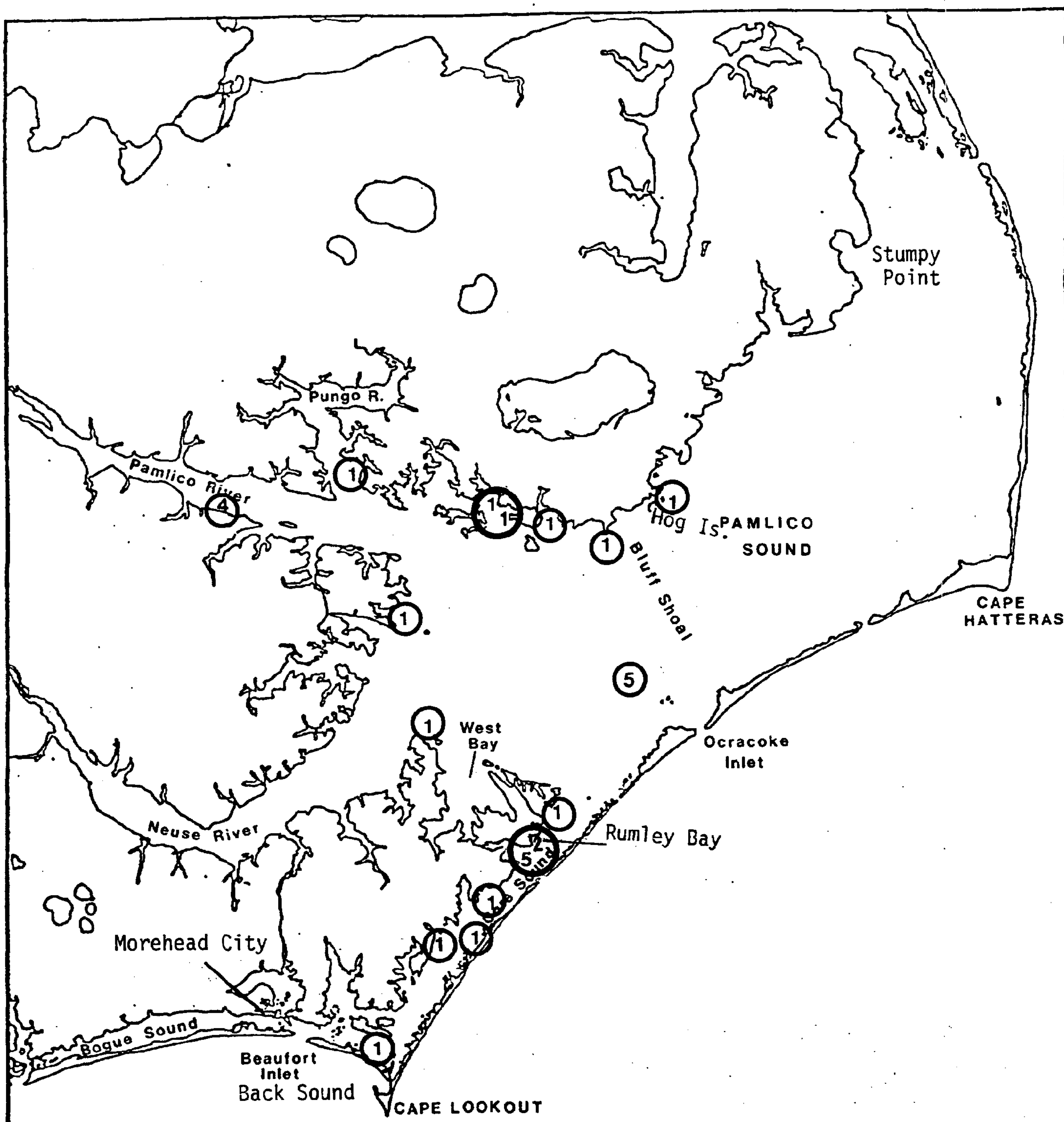

Figure 1. Circled numbers indicate locations (and number) of long haul seine catches sampled from October 1980 through July 1981 in North Carolina waters.

Table 1. Monthly composition and ranking[1] of species sampled from North Carolina commercial long haul catches, October 1980-July 1981.*indicates present in catch but not in subsamples. Numbers in parentheses indicate frequency of occurrence in catches sampled.

	Month						
	Oct	Apr	May	Jun	Jul	Total	% Total
No. of samples	13	1	6	5	4	29	
Species							
Leiostomus xanthurus	2143(13)	46	515(6)	1332(5)	837(4)	4873(29)	43.5
Micropogonias undulatus	144(12)	139	1218(6)	691(5)	481(4)	2673(28)	23.9
Brevoortia tyrannus	990(11)	*	229(3)	71(4)	47(4)	1337(22)	11.9
Lagodon rhomboides	1077(11)		14(1)	1(1)	4(1)	1096(14)	9.8
Cynoscion regalis	47(9)	2	93(4)	102(4)	171(4)	415(22)	3.7
Peprilus alepidotus	257(8)		1(2)	2(2)	98(4)	358(16)	3.2
Orthopristis chrysoptera	372(10)			3(1)	4(2)	379(13)	0.7
Bairdiella chrysoura	4(3)	1	18(2)	5(2)	38(3)	66(11)	0.6
Chaetodipterus faber	35(8)		*(1)	*(2)	30(2)	65(13)	0.6
Chloroscombrus chrysurus	45(8)					45(8)	0.4
Pomatomous saltatrix	13(11)		3(3)	6(4)	15(4)	37(22)	0.3
Callinectes sapidus	*(3)		3(4)	*(3)	20(3)	23(13)	0.2
Paralichthys dentatus	5(4)		3(2)	3(5)	10(3)	20(14)	0.2
Dasyatis sabina	16(7)		*(2)	1(1)	2(3)	19(13)	0.2
Peprilus triacanthus	3(3)		5(2)	*(1)	10(3)	18(9)	0.2
Paralichthys lethostigma	3(6)		4(2)	2(2)	8(3)	17(13)	0.2
Menticirrhus americanus	1(6)			3(3)	11(4)	15(13)	0.1
Selene vomer	2(3)			1(1)	10(4)	13(8)	0.1
Prionotus scitulus	11(4)					11(4)	0.1
Prionotus evolans	7(6)				1(1)	8(7)	0.1
Opisthonema oglinum	6(2)					6(2)	0.1
Monacanthus hispidus	6(6)					6(6)	0.1
Sphoeroides maculatus	4(3)		*(1)			4(4)	<0.1
Cynoscion nebulosus	2(6)	*	*(2)		2(3)	4(11)	<0.1
Caranx hippos	3(5)					3(5)	<0.1
Eucinostomus argenteus	3(2)					3(2)	<0.1
Rhinoptera bonasus	3(3)		*(1)	*(1)		3(5)	<0.1
Squid			*(1)	2(1)	1(1)	3(3)	<0.1
Caranx ruber	2(2)					2(2)	<0.1

Table 1 . (Continued)

	Month						
	Oct	Apr	May	Jun	Jul	Total	% Total
No. of samples	13	1	6	5	4	29	
Species							
Prionotus tribulus	1(2)		*(1)	1(1)		2(4)	<0.1
Chilomycterus schoepfi	1(4)		*(1)	*(1)	*(1)	1(7)	<0.1
Raja eglanteria	1(2)			*(1)		1(3)	<0.1
Synodus foetens	1(2)					1(2)	<0.1
Dorosoma cepedianum	*(1)		1(1)		*(1)	1(3)	<0.1
Acipenser oxyrhynchus			1(1)			1(1)	<0.1
Trachinotus carolinus			1(1)		*(1)	1(2)	<0.1
Ancylopsetta quadrocellata				1(2)		1(2)	<0.1
Menticirrhus saxatilis	*(2)					*(2)	
Mycteroperca microlepis	*(2)					*(2)	
Trichiurus lepturus	*(2)		*(1)	*(2)		*(5)	
Dasyatis sayi	*(1)			*(1)		*(2)	
Carcharhinus sp.	*(1)		*(1)			*(2)	
Caretta caretta	*(2)					*(2)	
Limulus polyphemus	*(1)					*(1)	
Lepisosteus osseus	*(1)					*(1)	
Strongylura marina	*(1)					*(1)	
Carcharhinus milberti				*(1)	*(1)	*(2)	
Archosargus probatocephalus				*(1)		*(1)	
Mustelus canis					*(1)	*(1)	
Sciaenops ocellatus					*(1)	*(1)	
Number of species	42	6	25	27	26	20	

[1]Species ranked in order of total numerical abundance.

Table 2 . Monthly numbers and weights (kg) and percent number and weight (wt) for major commercial fishes (and other species combined) sampled from North Carolina long haul catches, October 1980 - July 1981.

Species	Oct N	Oct %N	Oct WT	Oct %WT	Apr N	Apr %N	Apr WT	Apr %WT	May N	May %N	May WT	May %WT
Leiostomus xanthurus	2143	41.1	297.6	53.2	46	24.5	3.0	11.6	515	24.4	37.1[1]	17.8
Micropogonias undulatus	144	2.8	14.7	2.6	139	73.9	22.3	85.3	1218	57.8	142.6[1]	68.4
Cynoscion regalis	47	0.9	25.6	4.6	2	0.5	0.7	2.6	93	4.4	15.8[1]	7.6
Brevoortia tyrannus	990	19.0	104.0	18.6					229	10.9	6.8[1]	3.3
Paralichthys lethostigma	3	0.1	2.0	0.4					4	0.2	1.9	0.9
Paralichthys dentatus	5	0.1	1.4	0.2					3	0.1	[1]	
Other species	1876	36.0	114.2	20.4	1	0.5	0.1	0.4	47	2.2	4.4[1]	2.1
TOTAL	5208		559.5		188		26.1		2109		204.5[1]	

Species	Jun N	Jun %N	Jun WT	Jun %WT	Jul N	Jul %N	Jul WT	Jul %WT	TOTAL N	TOTAL %N	TOTAL WT	TOTAL %WT
Leiostomus xanthurus	1332	59.8	47.6[1]	22.9	837	46.5	100.7	43.1	4873	43.5	486.0[1]	39.3
Micropogonias undulatus	691	31.0	132.0[1]	63.4	481	26.7	66.6	28.5	2673	23.9	378.2[1]	30.6
Cynoscion regalis	102	4.6	18.9[1]	9.1	171	9.5	44.0	18.8	415	3.7	105.0[1]	8.5
Brevoortia tyrannus	71	3.2	6.0	2.9	47	2.6	4.9	2.1	1337	11.9	121.7[1]	9.8
Paralichthys lethostigma	2	0.1	0.2[1]		8	0.4	1.6	0.7	17	0.2	5.5[1]	0.4
Paralichthys dentatus	3	0.1	3.3[1]	0.1	10	0.6	1.1	0.5	21	0.2	2.7[1]	0.2
Other species	26	1.2	7.25[1]	1.6	246	13.7	14.5	6.2	1869	16.7	136.6[1]	11.1
TOTAL	2227		208.1		1800		233.5		11205		1235.7[1]	

[1]Incomplete sample weights = all samples not weighed.

The smaller sized pinfish did not contribute greatly to the sample weights. Although other commercially important fishes such as flounders, bluefish, and harvestfish (*Peprilus alepidotus*) were often encountered in the long haul fishery, they rarely contributed significantly to the marketable foodfish catch (Tables 1 and 2). These data indicated that long hauling was predominantly a sciaenid fishery, spot, croaker, weakfish, spotted seatrout, and southern kingfish (*Menticirrhus americanus*) accounted for 71.2% of total numbers, while 78.5% of total weight was contributed by spot, croaker, and weakfish. Other important species (besides spot, croaker, and weakfish) such as bluefish, spotted seatrout, red drum (*Sciaenops ocellatus*) southern kingfish were encountered in small numbers in our samples (Table 1). Occasionally large quantities of these fishes generally considered to be recreational will be landed (K. B. West, pers. comm.); however, they form a small percentage of the overall landings

Landings data (Table 3) indicated that the fall long haul fishery was dominated by spot, with croaker and weakfish also contributing major proportions. Unclassified scrap landings composed 51% of the total October landings and 12% of the November landings. This category contained large numbers of small (young-of-the-year) spot, croaker, and weakfish. Most of the long haul activity ended during November. In addition to the fall landings being heavily skewed toward spot, the location of the fishery shifted during the fall from all over the Pamlico Sound area to a more concentrated effort in Core Sound. After a winter lull, long haul activity began in April, and the landings data (Table 3) showed that croaker was the primary species from April through June, followed by weakfish and spot. During this time the fishery was spread throughout Pamlico Sound and its tributaries.

Overall landings for the nine month study period (Table 3) ranked croaker first, 29.5% of total kg landed, followed by spot, 21.0%, and weakfish, 7.5%. The scrap category was consistently a large proportion of each month's catch and comprised 37.5% of the total landings (October-June).

Data collected from the sampled long hauls (Tables 1 and 2) indicated trends similar to the overall landings (Table 3). Spot dominated the samples in October. Some species such as menhaden and pinfish which were numerically abundant entered the scrap catetory. Other fishes such as pigfish (*Orthopristis chrysoptera*), harvestfish, croaker, and weakfish were marketed both as food fish and scrap depending on the sizes landed. Spring samples (April-May, Tables 1 and 2)

Table 3. Monthly long haul seine landings* (kg) of selected species from October 1980 through June 1981. The figures are from an area covering Pamlico Sound south of Roanoke Island, Core Sound, Neuse River, Pamlico River, North River (Carteret Co.) and their major tributaries. Data are from the Division of Marine Fisheries-National Marine Fisheries Service statistics program.

Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Leiostomus xanthurus	649,897	88,113	0	0	0	0	9,009	45,401	72,227	864,647
Micropogonias undulatus	66,586	21,185	111	0	0	0	200,653	500,824	488,122	1,277,481
Cynoscion regalis	104,452	15,218	200	0	0	0	56,699	81,933	68,875	327,377
Cynoscion nebulosus	5,881	1,428	0	0	0	0	272	288	815	8,684
Paralichthys spp.	4,612	14,234	0	0	0	0	227	934	2,185	22,192
Scrap (non food)	982,838	25,785	1,100	0	0	0	114,624	265,406	228,949	1,618,702
Total (above species)	1,814,266	165,963	1,411	0	0	0	381,484	894,786	861,173	4,119,083
Total (all species)	1,921,501	192,480	1,431				385,684	942,208	876,641	4,319,945

*Preliminary landings, data subject to revision in Fishery Statistics of the United States.

indicated a dominance of croaker. Discrepancies between catch sampling data and overall landings were partly due to our sampling monthly in the Pamlico Sound area south of Bluff Shoal (Figure 1). There was considerable long haul activity north of Bluff Shoal, especially in the Stumpy Point area, and much of these landings were dominated by large croaker (K. B. West, pers. comm.).

Figures 2-5 depict the monthly size distributions of weakfish, menhaden, spot, and croaker collected in our long haul samples. Monthly sizes of other commonly encountered fishes in the samples did not exhibit clear growth patterns (Table 4) due to the small numbers in the samples during most months. Based on literature some age compositions of a few species were discernable, particularly in October (Table 4). Pinfish were represented by young-of-the-year (age 0), age 1, and age 2 fish, with the majority in October being age 1 (Caldwell 1957). Pigfish were ages 1 and 2 which overlapped broadly (Taylor 1916; Hildebrand and Cable 1930). Silver perch (*Bairdiella chrysoura*) in the long haul samples were mostly age 1 (Hildebrand and Cable 1930). Bluefish ranged from age 0 through age 2 (Lassiter 1962). Summer flounder were ages 0 and 1 (Powell 1974) and southern flounder were mostly ages 1 and 2 (DeVries 1981a).

Weakfish caught in long hauls ranged in size from 142 mm to 444 mm TL (Figure 2). This species was not abundant enough in the samples to indicate monthly growth or distinct age groups in the length frequency graph (Figure 2). Using Merriner's (1973) aging data for North Carolina, weakfish in our samples ranged from age 1 (yearlings) to approximately age 4.

Atlantic menhaden ranged from 83 mm to 301 mm FL (Figure 3). According to published length-age relationship data (McHugh et al. 1959; Reintjes 1969), long haul samples in October contained mostly ages 0 and 1 with a few fish of age 2. Samples from May through July were composed of a mixture of age 0 and 1 fish.

The size range of spot from the long haul samples was 89 mm - 268 mm FL (Figure 4). The October 1980 catch contained the largest, oldest fish as well as the greatest numbers. The majority (58.8%) of the October spot were yearlings (age class 1), ranging in size from 160 to 260 mm FL (Table 5). Young-of-the-year composed 27.3% of the October total followed by age class 2 at 12.0%. Spot rarely live to age class 3 (Sundararaj 1960); therefore, this group formed a very small percentage (1.8%, Table 5). Age classes 1-3 exhibited a large size overlap (Table 5). October data were separated because the long haul fishery is almost

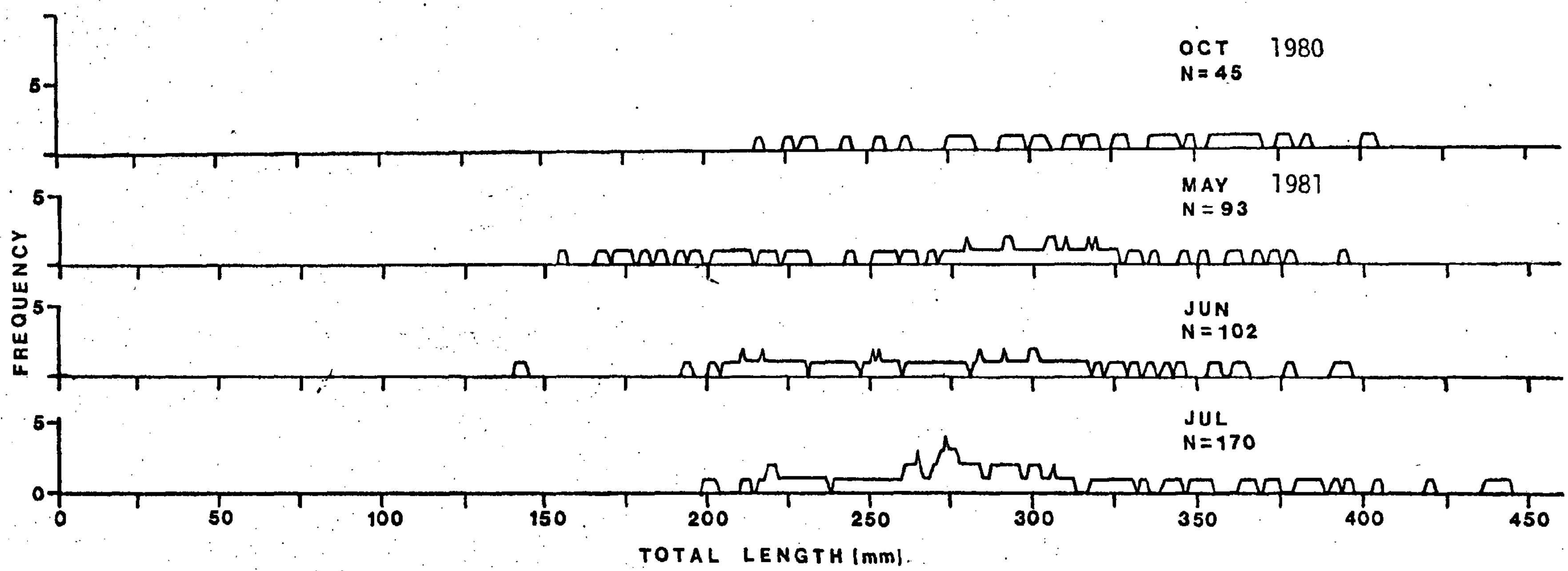

Figure 2. Monthly length frequencies of *Cynoscion regalis* from samples of North Carolina long haul seines. Frequencies are moving averages of three.

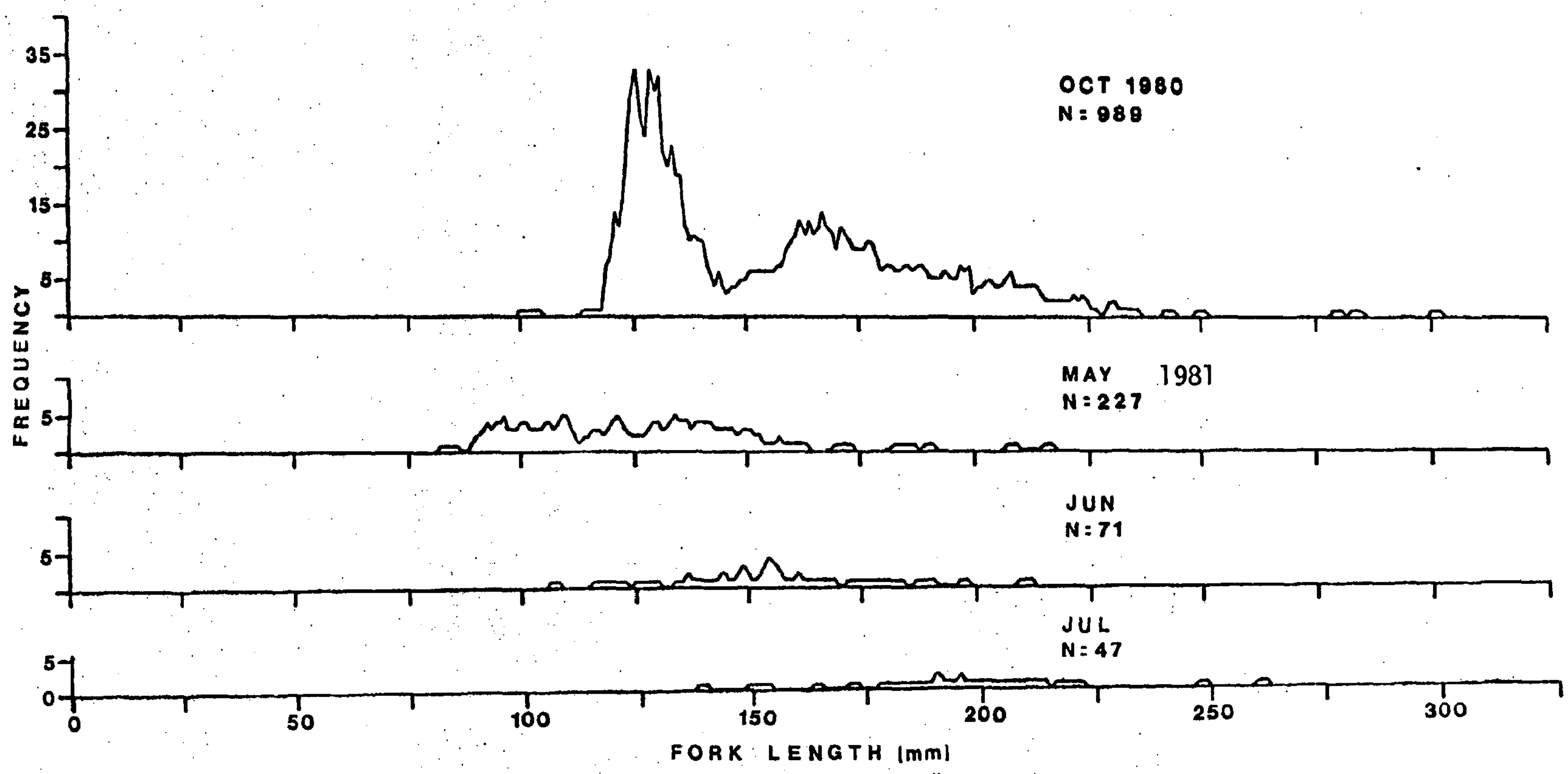

Figure 3. Monthly length frequencies of *Brevoortia tyrannus* from samples of North Carolina long haul seines. Frequencies are moving averages of three.

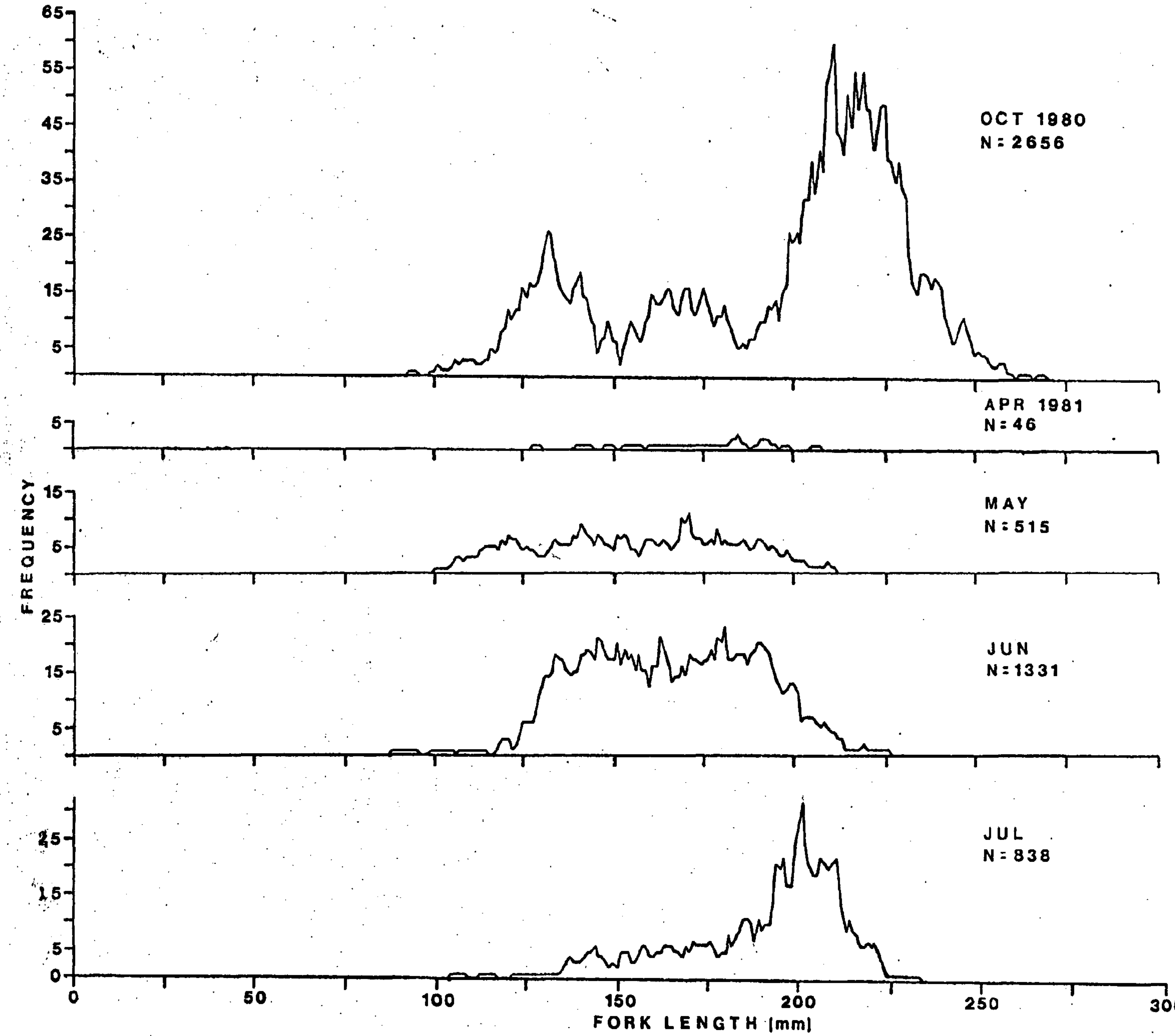

Figure 4. Monthly length frequencies of *Leiostomus xanthurus* from samples of North Carolina long haul seines. Frequencies are moving averages of three.

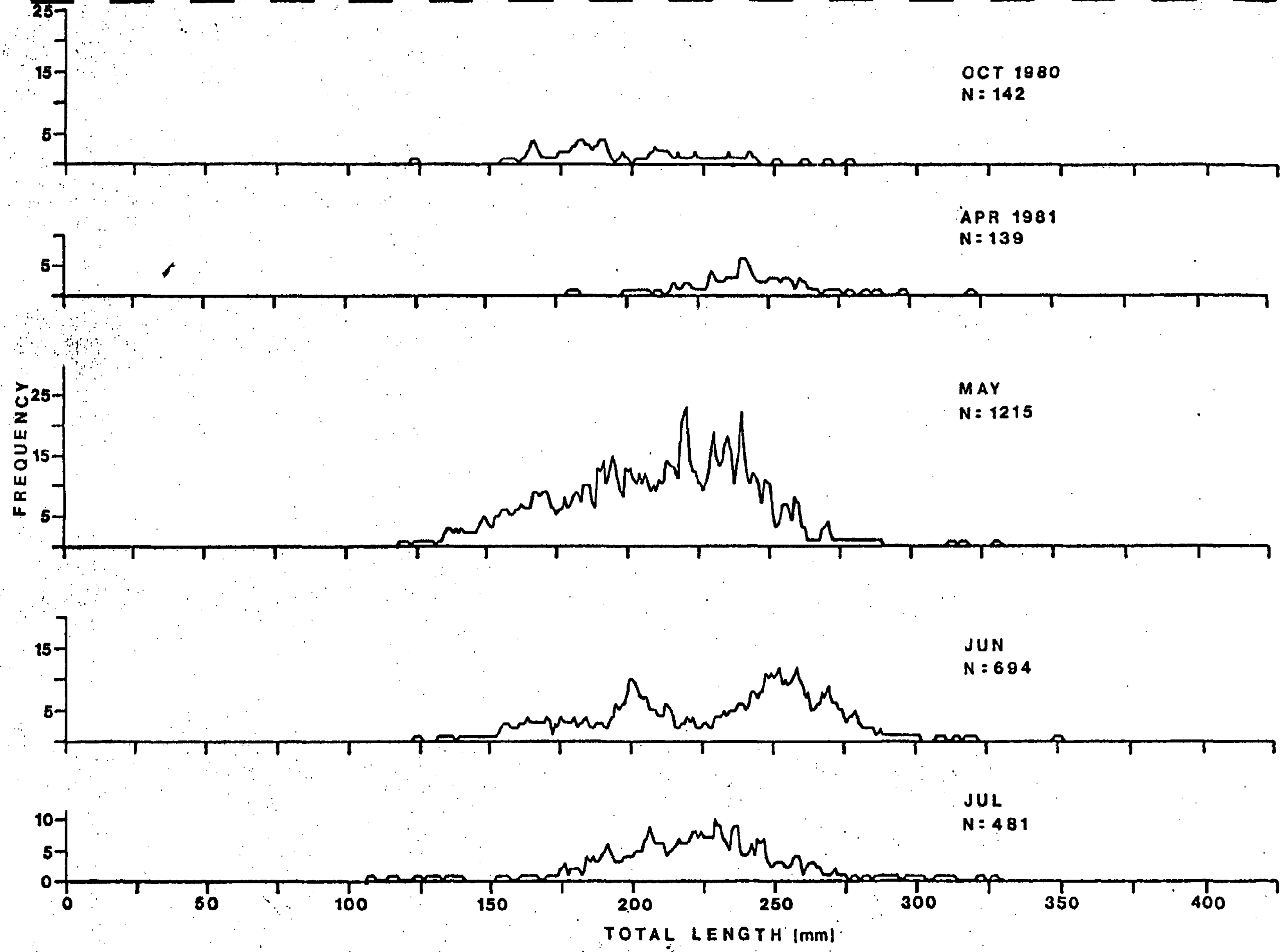

Figure 5. Monthly length frequencies of *Micropogonias undulatus* from samples of North Carolina long haul seines. Frequencies are moving averages of three.

Table 4. Monthly length frequencies of fish species (excluding spot, croaker, weakfish, and menhaden) comprising ≤0.2% of the long haul samples from October 1980 through July 1981. DW = disk width, FL = fork length, TL = total length.

Length Range (mm)	*Lagodon rhomboides* (FL) O	A	M	J	J	*Peprilus alepidotus* (FL) O	A	M	J	J	*Orthopristis chrysoptera* (FL) O	A	M	J	J	*Bairdiella chrysoura* (TL) O	A	M	J	J	*Chaetodipterus faber* (TL) O	A	M	J	J	*Chloroscombrus chrysurus* (FL) O	A	M	J	J
<90	34					47				96							5				21				17	12				
90-109	188					144															18				13	28				
110-129	163		10			61		1			54					3		2			1					4				
130-149	209		3	1	1	1			2		120							4		1										
150-169	301		1		3					2	117				1			3		6										
170-189	56					1					34			2	1			5	1	15	1									
190-209	3										32			1	1	1	1	3	4	11										
210-229											4									4										
230-249											3																			
250-269											3																			

Length Range (mm)	*Pomatomous saltatrix* (FL) O	A	M	J	J	*Paralichthys dentatus* (TL) O	A	M	J	J	*Dasyatis sabina* (DW) O	A	M	J	J	*Peprilus triacanthus* (FL) O	A	M	J	J	*Paralichthys lethostigma* (TL) O	A	M	J	J
<90																									
90-109										1															
110-129					1					1								1							
130-149					2					1								3		3					
150-169					2	1				1						1		1		1					
170-189					3					3	1					2									
190-209	2			1	1	1				1	8												1		1
210-229	2		1		1						5				1								1		
230-249	5					1			2		2			1											2
250-269	1			1		1			1																3
270-289	5		2	1	2	1																			1
290-309	3			3	2			2		1					1						1				
310-329	2							1															1		
330-349	1																				1				
350-369																							1		
370-389																								1	
≥390																					1			1	

Table 5. Estimated size and age relationship of October 1980 spot from long haul catch samples.

Size interval (mm)	Observed frequency	Percentages of observed sizes at age — Age classes 0	1	2	3
90- 99	1	100			
100-109	19	100			
110-119	36	100			
120-129	129	100			
130-139	182	100			
140-149	111	100			
150-159	67	100			
160-169	127	50	50		
170-179	131	50	50		
180-189	80	20	80		
190-199	129	25	75		
200-209	337		100		
210-219	503		91	9	
220-229	436		80	20	
230-239	211		50	38	12
240-249	103			80	20
250-259	32		40	60	
260-269	6		25	75	
270-279					
280-289					
290-299					
300-301					
Total % age composition		27.3	58.8	12.0	1.8
Total no. at age		722	1553	318	47

entirely directed toward spot during this month and occurs in a relatively enclosed locality (Core Sound). Spot age composition data from April through July 1981 (Table 6) indicated a predominance of yearlings (97.8% of the total). Only 2.2% of the spring and early summer spot were age class 2. Young-of-the-year fish were generally too small to enter the fishery prior to July when a few individuals may have been age 0. A detailed description and validation of spot aging was presented by DeVries (1981a); therefore, some information, such as back-calculated lengths and marginal increments, is not included here.

Very little aging data exist for croaker on the U.S. east coast; therefore, this project concentrated on aging this species. Five hundred and eighty-five fish (107-358 mm FL) were aged using scales from October 1980 through July 1981. Most of the scale samples came from long haul catches, and supplemental scale samples were collected from a juvenile survey program, sinking gill net fishery, winter trawl fishery, pound net fishery, and miscellaneous sampling. Eleven scale samples (2% of total) were considered unreadable.

A linear relationship between scale radius (SR) and total length (TL) was expressed by the formula,

$$TL=43.5 + 2.23\ (SR),$$

with a high correlation coefficient ($r = 0.969$). The y-intercept (43.5) became the correction factor used in the Lee (1920) back-calculation equation. Mean weighted back-calculated lengths at age were: age 1 - 178.8 mm, age 2 - 252.9 mm, age 3 - 293.6 mm, and age 4 - 323 mm (Table 7). Back-calculated length frequencies (Figure 6) indicated that marks in the four age classes formed at a similar size range. Age classes 2-4 exhibited large overlap which is expected in fish with rapid growth and very extended spawning seasons.

Monthly frequency of marginal increments (Figure 7) exhibited wide variability and was somewhat inconclusive for the third and fourth annuli. Increment data for annuli 1 and 2 indicated that annual marks were formed in the late spring (April-May), although some marks may form as early as January. Unlike a previous study from the Gulf of Mexico (White and Chittenden 1977), North Carolina croaker usually form one mark a year.

Croaker in the long haul catch samples ranged from 108 - 352 mm TL (Figure 5). Age classes were not apparent from the length-frequency data (Figure 5). The age

Table 6. Estimated size and age relationship of April-July 1981 spot from long haul catch samples.

Size interval (mm)	Observed frequency	Percentages of observed sizes at age: Age classes 0	1	2	3
80- 89	1		100		
90- 99	2		100		
100-109	24		100		
110-119	54		100		
120-129	101		100		
130-139	219		100		
140-149	284		100		
150-159	270		100		
160-169	273		100		
170-179	307		100		
180-189	334		100		
190-199	362		100		
200-209	329		100		
210-219	129		71	29	
220-229	35		40	60	
230-239	1			100	
Total % age composition			97.8	2.2	
Total no. at age			2666	58	

Table 7. Mean back-calculated total lengths (mm) and standard deviations (SD) for croaker, October 1980 - July 1981.

Age class	N*	1	SD	2	SD	3	SD	4
1	146	169.1	39.4	-		-		-
2	180(85)	180.7	31.1	244.7	31.3			-
3	88(19)	191.6	28.4	260.4	25.7	289.1	33.2	-
4	10(1)	172.1	22.1	256.1	25.9	302.5	18.3	323
Mean weighted TL		178.8		252.9		293.6		323.0
Total N		424		183		29		1

*Numbers in parenthesis equal number of fish in last age class. Number of fish in last age class do not equal number in previous age classes because some of the fish in a particular age group had not yet formed the final annulus.

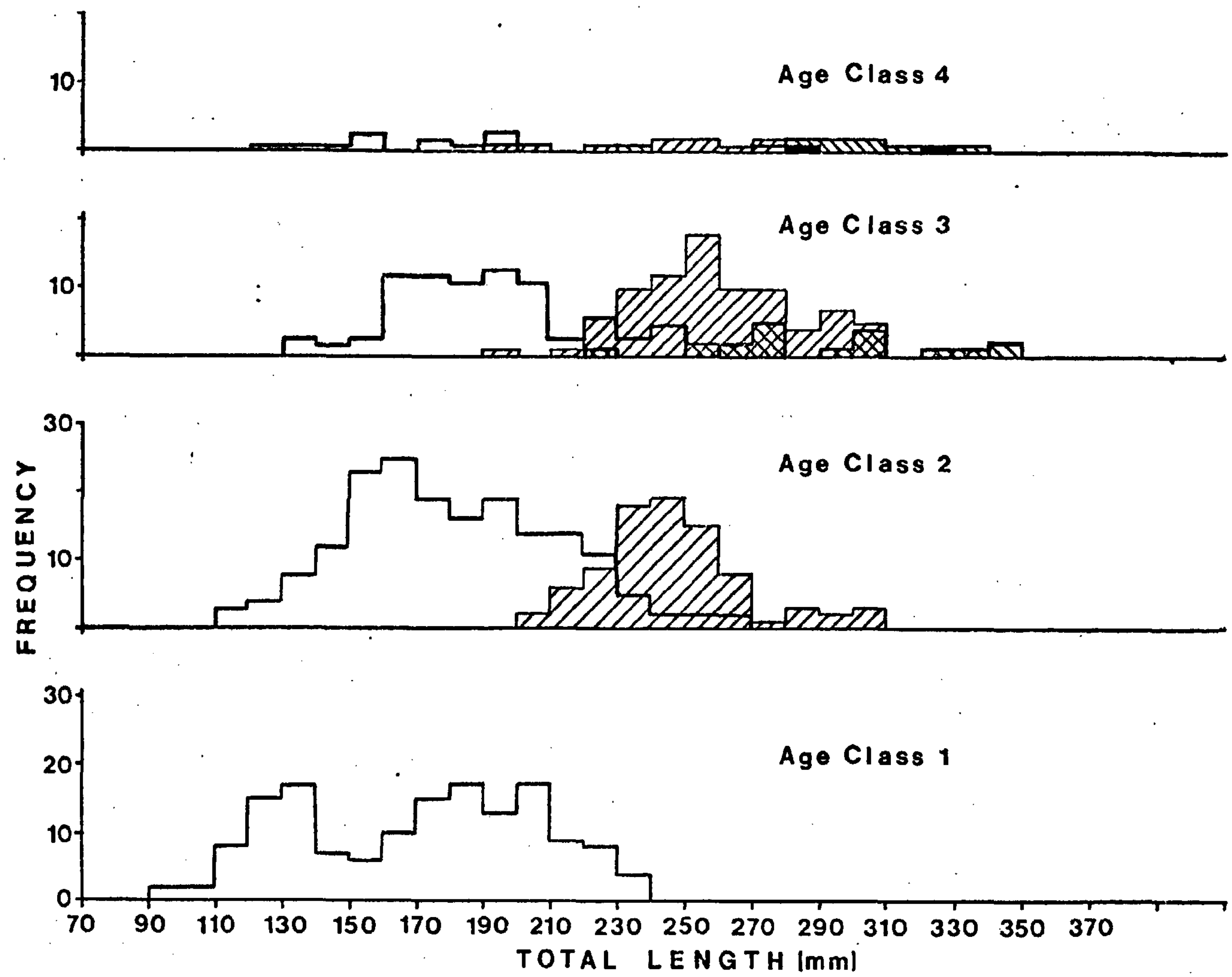

Figure 6. Back-calculated length-frequencies for croaker age classes from October 1980 through July 1981. ⊓ = first annulus, ▨ = second annulus, ▧ = 3rd annulus, ■ = 4th annulus.

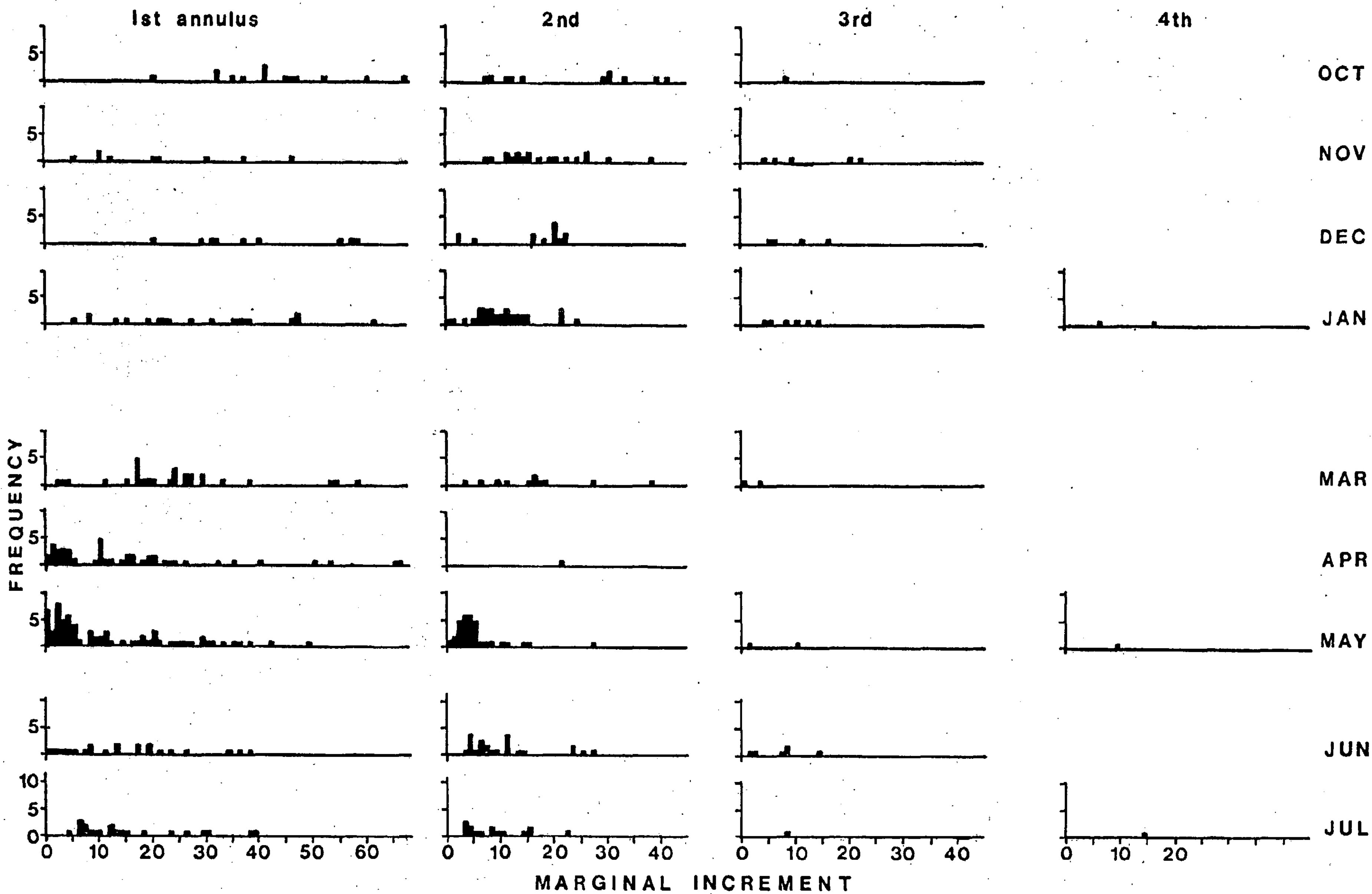

Figure 7. Monthly scale marginal increments for *Micropogonias undulatus* from October 1980 through July 1981. Scales were magnified 24 X, and all measurements were in mm.

distribution of October 1980 long haul croaker indicated that 90% were yearlings and 10% were age class 2 (Table 8). Croaker are generally neither abundant nor large during the fall. If there is a good period for croaker in the long haul fishery, it usually occurs in the spring and early summer. April - July 1981 age frequency data produced percentages of 0.1, 16.7, 81.3, 1.7, and 0.2 for age classes 0-4, respectively (Table 9). Our samples were predominantly age classes 1 and 2, and the data reflect that somewhat older, larger croaker occurred in the April - July period. Croaker are fully recruited into this fishery by age 1; however, young-of-the-year (age 0) enter the fishery in late summer and fall. Few age 0 fish are apparent in these data (Table 9, Figure 5).

Pound Net Fisheries

Pamlico Sound Sciaenid Fishery

In general the Pamlico Sound pound net operation occurs from spring through early fall and is directed toward sciaenids. Only two pound nets were sampled, one in western Pamlico Sound near Hog Island and the other in eastern Pamlico Sound near Hatteras. Both were sampled in July 1981, and the samples were dominated by croaker (32% by number, 48% by weight, Table 10). Spot, menhaden, bluefish, silver perch, and weakfish were also common in these samples. There are not enough data to adequately discuss more details of this fishery.

Core Sound Flounder Fishery

This pound net fishery usually operates from Ocracoke through the whole length of Core and Back Sounds from late September through December. The fishery is directed toward the yearly migration of paralichthid flounders toward the ocean.

Eight pound nets were sampled from 7 October through 13 November 1980 on the eastern side of Core Sound approximately opposite Rumley Bay. These samples yielded 35 fish species, two invertebrate species and one species of sea turtle (Table 11). Southern flounder, harvestfish, summer flounder, and Gulf flounder were the four most abundant species (96% by number), comprising 50.5, 38.4, 5.6, and 1.5% of the samples by number (Table 11). The three species of *Paralichthys* comprised 94.3% of the samples by weight, clearly dominating the fishery in all aspects.

Southern flounder was the most abundant flounder (87.7% by number, 94.7% by weight), followed by summer flounder (9.8 and 4.2% by number and weight) and Gulf

Table 8. Estimated size and age relationship of October 1980 croaker from long haul catch samples.

Size Interval (mm)	Observed frequency	Percentages of observed sizes at age — Age classes 0	1	2	3
100-109					
110-119					
120-129	1		100		
130-139					
140-149					
150-159	2		100		
160-169	18		100		
170-179	17		100		
180-189	33		100		
190-199	17		100		
200-209	8		100		
210-219	16		100		
220-229	11		88	12	
230-239	9		54	46	
240-249	6		19	81	
250-259	1			100	
260-269	1			100	
270-279	2			100	
280-289					
290-299					
300-309					
310-319					
Total % age composition			90	10	
Total no. at age			128	14	

Table 9. Estimated size and age relationship of April - July 1981 croaker from long haul catch samples.

Size interval (mm)	Observed frequency	Percentages of observed sizes at age — Age classes 0	1	2	3	4
100-109	1		100			
110-119	2		100			
120-129	11	11	89			
130-139	21		100			
140-149	35		100			
150-159	70		100			
160-169	102		100			
170-179	112		100			
180-189	212		100			
190-199	203		100			
200-209	250		100			
210-219	220		100			
220-229	263		88	12		
230-239	250		54	46		
240-249	287		19	81		
250-259	222		17	83		
260-269	129			100		
270-279	90		9	90		
280-289	38			89	11	
290-299	12			100		
300-309	8			60	30	10
310-319	9			33	58	9
320-329	5			25	75	
330-339	1				100	
340-349						
350-359	1				100	
Total % age composition		0.1	16.7	81.3	1.7	0.2
Total no. at age		1	1705	829	17	2

Table 10. Composition and ranking of species sampled from two Pamlico Sound "sciaenid" pound nets on 13 July 1981. *indicates present in catch but not in subsample. Numbers in parenthesis indicate frequency of occurrence in catches sampled.

Species	Number	Weight (kg)	Size Range (mm)
Micropogonias undulatus	129(2)	23.1	167-320
Leiostomus xanthurus	74(2)	6.1	110-200
Brevoortia tyrannus	65(2)	4.8	105-203
Pomatomus saltatrix	47(2)	1.8	112-217
Bairdiella chrysoura	45(1)	4.0	155-221
Cynoscion regalis	19(2)	5.8	215-322
Peprilus triacanthus	14(2)	0.9	120-156
Peprilus alepidotus	5(2)	0.5	140-168
Opisthonema oglinum	3(1)		175-189
Paralichthys dentatus	2(2)		180-292
Prionotus evolans	1(2)	0.8	135
Orthopristis chrysoptera	1(1)		283
Trinectes maculatus	1(1)		130
Trachinotus carolinus	*(1)		
TOTAL	406	47.8	

Table 11. Species composition (numbers and weights, kg) of eight Core Sound "flounder" pound nets samples during October - November 1980. Size ranges are fork length unless otherwise noted. * indicates species observed in catch but not sampled.

Species	No.	%	Wt	%	No. catches in which species was observed	Size range (mm)
Paralichthys lethostigma	1172	50.5	865.7	89.3	8	265-606 TL
Peprilus alepidotus	892	38.4			7	94-204
Paralichthys dentatus	131	5.6	38.8	4.0	8	209-475 TL
Paralichthys albigutta	34	1.5	9.5	1.0	7	172-342 TL
Leiostomus xanthurus	16	0.7			8	268-311
Pomatomus saltatrix	9	0.4	55.8[1]	5.8	7	304-464
Peprilus triacanthus	9	0.4			3	182-190
Chaetodipterus faber	9	0.4			4	112-136
Selene vomer	8	0.3			3	118-150
Cynoscion regalis	5	0.2			6	432-516
Micropogonias undulatus	5	0.2			5	302-367 TL
Archosargus probatocephalus	5	0.2			3	335-498
Brevoortia tyrannus	4	0.2			4	215-323
Lagodon rhomboides	3	0.1			3	206-288
Monacanthus hispidus	3	0.1			3	164-254 TL
Sciaenops ocellatus	3	0.1			4	377-527
Mugil cephalus	2	0.1			3	365-371
Ancylopsetta quadrocellata	2	0.1			2	246-285
Scophthalmus aquosus	2	0.0			5	210-239
Sphoeroides maculatus	2	0.1			3	263-277
Chilomycterus schoepfi	2	0.1			4	154-300
Trachinotus carolinus	1	<.1			3	318
Astroscopus guttatus	1	<.1			4	380
Scomberomorus maculatus	1	<.1			2	344
Aluterus schoepfi	1	<.1			3	319 TL
Callinectes sapidus	1	<.1			2	142
Dasyatis sabina	*				1	
Rhinoptera bonasus	*				1	

Table 11 . (continued)

Species	No.	%	Wt	%	No. catches in which species was observed	Size range (mm)
Dorosoma cepidianum	*				1	
Trachinotus falcatus	*				1	
Orthopristis chrysoptera	*				1	
Cynoscion nebulosus	*				2	
Menticirrhus americanus	*				2	
Pogonias cromis	*				1	
Prionotus evolans	*				2	
Trinectes maculatus	*				1	
Limulus polyphemus	*				2	
Caretta caretta	*				1	

[1]Weight of all remaining species

flounder (2.5 and 1.0% by number and weight). Although spot and some other sciaenids were being taken by the long haul fishery during the same time in Core Sound, these fishes were very rare in the pound nets. Other important species besides spot and flounder comprised less than 0.7% of the total samples by number.

Monthly pound net landings from Core Sound (Table 12, October-December 1980), indicated that October was the most successful month. *Paralichthys spp.* made up 82.7% of the total landings in October, 98.3% in November, and 97.2% in December. *Peprilus spp.* was the second most important category in all three months. These data (Table 12) agree well with the samples collected from various catches (Table 11).

Southern flounder from the pound nets ranged from 265-606 mm TL (Figure 8) with an average weight of 0.75 kg. Age class 1 comprised 51.5%, age class two 45.1%, and age class three 3.3%. More detailed data on aging of southern flounder in North Carolina, including validation of the aging technique was presented by DeVries (1981a). Summer flounder ranged from 209 to 475 mm TL (Figure 9), having an average weight of 0.30 kg. These fish seemed to be primarily late one year-olds based on Smith and Daiber's (1977) back-calculated length at age two of 260 mm TL in Delaware Bay. Gulf flounder lengths ranged from 172 to 342 mm TL (Figure 9) with a mean weight of 0.28 kg.

DISCUSSION

Long Haul Seine Fishery

DeVries (1981b) presented detailed information on the long haul fishery from a broad area of western Pamlico Sound, Core Sound, and their tributaries, including catch and age data. Guthrie et al. (1973) gave a description of fishing methods and some historical perspective, reporting that this fishery started in North Carolina around 1910. Contrary to this, Earll (1887) reported that the haul seine fishery (then called drag nets) began soon after 1800 and was directed largely toward weakfish. By 1925 the fishery was well developed with techniques that have changed little since that time (Higgins and Pearson 1928).

Seasons of the fishery in its earliest days were not always consistent, and the fishery often targeted on one or two species such as spotted seatrout in the spring and fall (Earll 1887). Guthrie at al. (1973) stated that the fishery was originally conducted only in October and November for spot; however, he was

Table 12. Monthly pound net landings *(kg) for selected species from Core Sound, N.C. from October through December 1980.

Species	Month Oct	Nov	Dec	Total
Leiostomus xanthurus	838	0	0	838
Micropogonias undulatus	179	0	0	179
Cynoscion regalis	116	0	0	116
Paralichthys spp.	116,465	93,341	16,465	226,271
Peprilus spp.	21,909	1,476	379	23,764
Pomatomus saltatrix	129	0	0	129
Archosargus probatocephalus	1,114	168	0	1,282
Scrap	0	0	0	0
TOTAL (above spp.)	140,750	94,985	16,844	252,579
TOTAL (all spp.)	143,180	96,449	16,844	256,473

*Preliminary landings, subject to revision in Fishery Statistics of the United States.

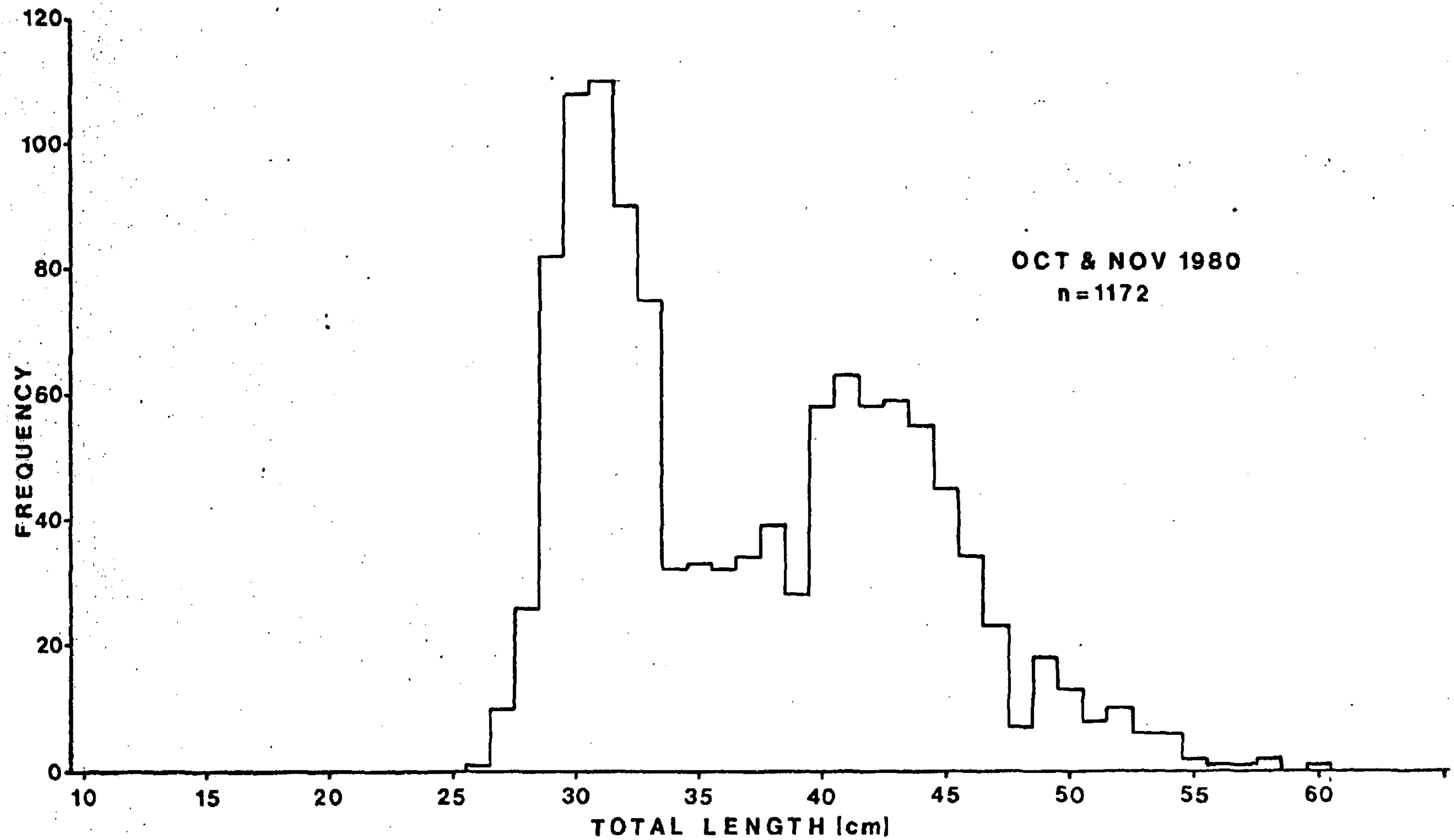

Figure 8. Length frequencies of *Paralichthys lethostigma* in October and November 1980 from Core Sound pound net samples.

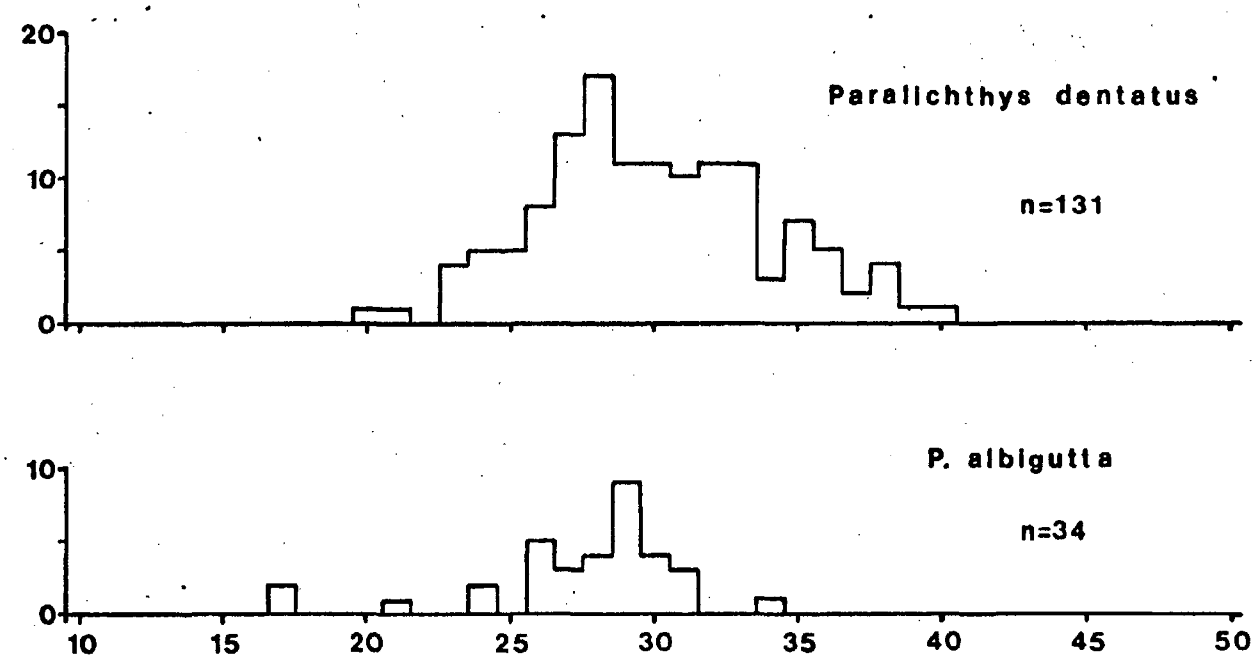

Figure 9. Length frequencies of *Paralichthys dentatus* and *P. albigutta* from October and November 1980 Core Sound pound nets.

probably only referring to the Core Sound area. Data in this report indicate that long hauling is a mixed species fishery dominated by sciaenids (Tables 1 and 2). The fishery starts either in March or April and continues through December, although most activity is over by early November. In general, croaker dominate the spring catches, and fishing is widespread in Pamlico Sound and its tributaries. By fall the fishery is almost completely in Core Sound and is directed toward spot. Roelofs (1951) remarked on this consistent pattern in the fall spot fishery. Although weakfish is not always abundant, it can contribute a large percentage of some catches at various locations and times. Previous studies (Higgins and Pearson 1928: DeVries 1981a, 1981b) yielded similar results on fishing localities and major species.

The long haul seine is a very efficient gear, capturing nearly all species and sizes of fishes that it encounters. The species list in Table 1 and those of Guthrie et al. (1973) and DeVries (1981a, 1981b) indicate a large catch diversity. It should be noted that the variability in the number of species and the size range of fishes among individual catches can be high depending on the season and the habitat the net crosses.

The two major species in this study, spot and croaker, were mainly represented by yearling (age class 1) fish. Young-of-the-year for both species began recruiting to this fishery during late summer and were well represented, especially for spot in the fall (see October data, Figures 4 and 5). Although these young-of-the-year can be quite numerous in fall catches, they are too small to be marketed as food and thus are part of the scrap landings. Long haul samples during 1978 (Sholar 1979) also revealed that yearling spot and croaker were the most abundant. Age class 1 also dominated both spot and croaker samples in 1979 (Ross 1980; DeVries 1981a), except that for croaker age class 2 was noticeable in April and abundant in May (Ross 1980). Fifty-six years ago the size-age structure of the long haul fishery was very similar (Higgins and Pearson 1928). This is particularly interesting since Higgins and Pearson used the same techniques to sample the fishery as the North Carolina Division of Marine Fisheries has used since 1978. The available data seem to indicate that the age structure of the long haul fishery overall is fairly stable.

Since the fishery is based on one or two year classes (1 and 2) and since the major species, spot and croaker, are short lived (3-5 years maximum), this fishery should be very vulnerable to the success of any one year class. Drastic fluctuations in long haul landings would not be surprising and have occurred. Overall landings were particularly low from 1965 to 1972, increasing steadily to a record high in 1979 (DeVries 1981b). DeVries pointed out that the landing fluctuations were not necessarily linked to fishing effort..

The most detailed report on croaker aging to date was accomplished in the western Gulf of Mexico by White and Chittenden (1977). Their fish were aged by scales, and many of their techniques were similar to those of this report. A major finding of White and Chittenden was that croaker in the Gulf seemed to form two marks per year. Contrary to this the North Carolina specimens aged for this project usually formed one mark per year. The reasons for this difference in scale marking are not yet determined. Although croaker length-frequencies from October 1980 through July 1981 only indicate a clear peak for age class one, the mean back-calculated lengths at age (Table 7) are similar to those calculated in 1979 and closely match the April-May 1979 estimated ages on the length-frequencies (see Figure 5, Ross 1980).

Assuming the October birthdate, the young-of-the-year that became yearlings in October 1980 had a mean total length of 130 mm. These data were derived from a concurrent juvenile sampling program (Hawkins 1982), and this length is surely a minimum since it does not take into account emigration of the larger croaker out of the sampling area or gear avoidance by larger croaker. Length at year one in the fall from this study agrees well with that of other reports: 150 mm, Texas (Pearson 1929); 135 mm, Texas (Gunter 1945); 143 mm, North Carolina (Hildebrand and Cable 1930); 175-180 mm, Chesapeake Bay (Haven 1959); 150 mm, Gulf of Mexico (White and Chittenden 1977). The mean weighted back-calculated length at first annulus (which probably formed during April and May) was 178.8 mm (Table 7).

White and Chittenden (1977) report an observed size range of 190-360 mm in October for age class 2 croaker and a mean back-calculated length at age 2 of 270 mm (based on six fish collected in March). The North Carolina data indicate that this length range in October was occupied by age classes 2 (one mark on scales) and 3 (two marks on scales). The mean weighted size back-calculated to age 2 was 253 mm (n=183, Table 7). Differences in aging results between the Gulf of Mexico and the Atlantic Coast need to be burther evaluated. Perhaps an examination of more large croaker (>age 1) from the Gulf would clarify the double mark per year phenomenon.

Core Sound Flounder Pound Net Fishery

Pound nets were first used in Core Sound in 1879 and were originally unsuccessfully fished for weakfish or speckled trout (Earll 1887). They were eventually removed and fished in the rivers and in Pamlico Sound for sciaenids and clupeids (shad and herring). The fishery in Core Sound as it presently exists is relatively young, probably less than 20 years old (Billy Smith, pers. comm.). DeVries (1981a) described the gear and techniques presently used in Core Sound pound nets, including information on catches.

Flounder pound net data from October-November 1980 were very similar to that of 1979 (DeVries 1981a). Three fish species observed in 1979 were not present in 1980, and 7 fishes, 1 invertebrate, and the loggerhead turtle appearing in the 1980 samples were absent in 1979. Southern flounder, harvestfish, summer flounder, and Gulf flounder were the four most abundant fishes in both years. The three paralichthid species composed 93.1% of the total weight in 1979 and 94.3% in 1980.

Although the Core Sound pound nets capture a wide diversity of species (Table 11), quantities of fishes other than flounders and harvestfish are uncommon. This is particularly interesting for spot which is very abundant in Core Sound in the fall and is harvested heavily by long haul seines. This distinct catch separation is possibly due to the differing migratory habits of the spot and flounders. Both species are migrating through Core Sound toward the ocean (generally going from north to south). Spot seemingly use the deeper channels on the western side of Core Sound; therefore, the long haul fishery concentrates there. The paralichthid flounders appear to follow the shoals which are more extensive on the eastern side and are conducive to being "led" into the many pounds on that side. Spot probably do not lead well along the large mesh ($\approx$ 102 mm) used in the pound nets.

The age composition of the major species, southern flounder, was different between 1979 and data in this report, 1980. DeVries' (1981a) 1979 samples indicated the fishery was supported by ages 1-4 in the following percentages 20.9, 36.9, 41.7, and 0.4. The fishery shifted from being largely composed of three age classes to one with only two abundant classes (1 and 2) in 1980. The largest proportion, three-year olds, in 1979 was almost entirely absent in 1980. One-year olds increased from 20.5% in 1979 to 51.5% in 1980.

One possible reason for the age structure shift is that sampling in one or both years was not representative of the actual age composition. This seems unlikely since sampling was spread out over most of the fishing season and sampling effort was reasonably consistent. A more reasonable explanation is that natural variation in year class strength caused certain ages to be more abundant one year than the other. Another possible cause of age structure shift is that fishing pressure was so high that certain age classes were over-exploited before reaching full size or maturity (growth overfishing). Although pound net effort has increased steadily in recent years, this latter explanation is not necessarily the best. A combination of year class variability and exploitation may influence the yield in this fishery. Continued annual monitoring to analyze ages, growth, and mortality should indicate the controlling factors in the Core Sound pound net fishery.

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PROJECT I

ESTUARINE FISH STOCK ASSESSMENT

NURSERY AREA MONITORING

by

Jess H. Hawkins

ABSTRACT

One hundred and thirty-eight stations located in estuarine tributaries of North Carolina were sampled monthly during October and November, 1980 and March through July, 1981. Salinity and temperature data were recorded at each station. Salinities during the spring, 1981 were the highest recently documented for the tributaries of northern and western Pamlico Sound. Eighty-eight species of fish and 23 species of invertebrates were captured. The sciaenid family represented 72% of the total catch of fish. *Leiostomus xanthurus* was the most abundant fish captured, comprising 61% of the total catch. *Callinectes sapidus* was the most abundant invertebrate captured, representing 43% of the total invertebrate catch.

Temporal and spatial distributions, growth patterns, and relative abundances were briefly examined for *Brevoortia tyrannus, Anchoa mitchilli, Bairdiella chyrsoura, Cynoscion regalis, L. xanthurus, Micropogonias undulatus, Paralichthys lethostigma, Penaeus aztecus, P. duorarum, P. setiferous,* and *C. sapidus*. Peak abundance of sampled fauna in estuarine tributaries occurred during spring, corresponding with recruitment of young-of-the-year for the majority of estuarine species. *B. tyrannus, L. xanthurus, P. lethostigma, P. azterus,* and *P. duorarum* recruited during spring, while *B. chyrsoura, C. regalis,* and *P. setiferous* recruited during June and July. Small young-of-the-year *M. undulatus* (less than 35 mm TL) were captured in fall and spring. *A. mitchilli* and *C. sapidus* recruits were captured from March through July. Most species preferred shallow tributaries as initial recruitment habitat; however, large numbers of *C. regalis, B. chyrsoura,* and *M. undulatus* recruits were captured in deeper waters. Growth was rapid for most species sampled, especially *C. regalis, B. chrysoura,* and *M. undulatus*. Several size classes of most fish species were captured in estuarine tributaries. Large numbers of yearling *L. xanthurus* were present in catches during March through May. Catch per unit effort indicated *L. xanthurus* were more abundant and *M. undulatus* less abundant in estuarine tributaries of Pamlico Sound during 1981 than during 1979 and 1980.

INTRODUCTION

Estuaries are highly productive water bodies. They serve as nursery areas for finfish and shellfish because of abundant food supplies, protection from predation and other factors (Gunter 1938, Dahlberg 1972, Weinstein 1979). Most sport and commercial fisheries are dependent upon the productivity of marshes and creeks (de la Cruz 1973 in Hackney et al. 1976). Over half of the nation's commercial fish, shellfish, and marine sportfish utilize estuaries (Smith 1966 in Hackney et al. 1976). North Carolina possesses 1.2 million ha of coastal marshes and estuarine waters (Wolff 1976). The Pamlico-Albemarle Sound system, containing 679,000 ha, ranks as the third largest North American estuarine system (Gross 1972).

Investigations were initiated in North Carolina by the North Carolina Division of Marine Fisheries during 1971 to study selected fauna in estuarine waters. Spitsbergen and Wolff (1974),Purvis (1976) and Wolff (1976) investigated the role of various estuarine areas as nursery grounds for juvenile fish and crustaceans. As a result of these studies, the North Carolina Marine Fisheries Commission enacted regulations in 1977 protecting designated nursery areas. Carpenter (1978, 1980) and Ross (1980, in press) briefly summarized subsequent Division investigations on juvenile fishes and crustaceans. Many additional North Carolina studies have involved pre-adult estuarine fish and crustaceans (Hildebrand and Cable 1930, Williams and Deubler 1968a, Kjelson et al. 1975, and Marshall 1976). Numerous estuarine studies have been completed in the lower Cape Fear River assessing the potential effects of a nuclear power plant on juvenile and adult estuarine species (Hobbie 1971; Copeland and Birkhead 1972, 1973; Weinstein 1979; Weinstein et al. 1980). Other studies in North Carolina waters involving juvenile estuarine-dependent fauna often have been species or family specific: *Cynoscion regalis* (Merriner 1973, 1975, 1976), *Paralichthys dentatus* and *P. lethostigma* (Deubler 1958, Powell 1974, Powell and Schwartz 1977, DeVries 1981, *Micropogonias undulatus* (Higgins and Person 1928, Roelofs 1954, Morse 1980), *Brevoortia tyrannus* Wilkins and Lewis 1971, Lewis and Mann 1971, Kroger et al, 1974), *Callinectes sapidus* (Fischler 1965; Dudley and Judy 1971, 1973), and penaeid shrimp (Williams 1979, McCoy 1968, Purvis and McCoy 1972).

The present study briefly summarizes the composition of a portion of the nekton community in North Carolina's estuarine tributaries for October and November

1980, and March to July, 1981. Temporal and spatial distributions, growth patterns, and relative abundances were analyzed for several commonly occurring estuarine species: spot, Atlantic croaker, weakfish, southern flounder, silver persh (*Bairdiella chrysoura*), bay anchovy (*Anchoa mitchilli*), Atlantic menhaden, blue crab, brown shrimp (*Penaeus aztecus*), pink shrimp (*P. duorarum*), and white shrimp (*P. setiferus*).

METHODS

Study Area

A total of 138 sampling stations were located through North Carolina's estuarine waters, from northern Pamlico Sound to the Cape Fear River (Figures 1-4). Stations were separated into primary and secondary nursery area sites according to the classification by Spitsbergen and Wolff (1974) and Purvis (1976). Stations were sampled monthly during October and November, 1980 and March through July,1981.

The study area was divided into three generalized sections (northern, central, southern) to simplify discussions. The northern section covers northern Pamlico Sound from Stumpy Point Bay westward, including the Pamlico and Pungo rivers (Figure 2). Pamlico Sound is the largest embayment formed behind barrier beaches along the Atlantic coast of the United States, consisting of a complex of drowned river valleys (Giese et al. 1979). The Sound is shallow (mean depth - 4.6 m) and extends 113 km longitudinally and 17 to 48 km latitudinally. The bottom types vary from sand to mud, with extensive shoaling along the shorelines, grading into extensive marshes. The marshes are typified by low-lying pine pocosin drainage, bordered by black needlerush (*Juncus roemerianus*) along the estuarine zones. (Purvis 1976).

Lunar tidal oscillations are negligible, due to restricted water circulation through the few narrow inlets (Ocracoke, Hatteras, and Oregon). The shallowness of Pamlico Sound allows wind to thoroughly mix its waters throughout most of the year. Wind tides of 0.6 m are not uncommon (Street and McClees 1981). The horizontal salinity distribution is influenced by wind tides and seasonal variation in river discharge. Salinities generally range from 0 parts per thousand (ppt) in the upper tributaries to about 25 ppt near the three inlets.

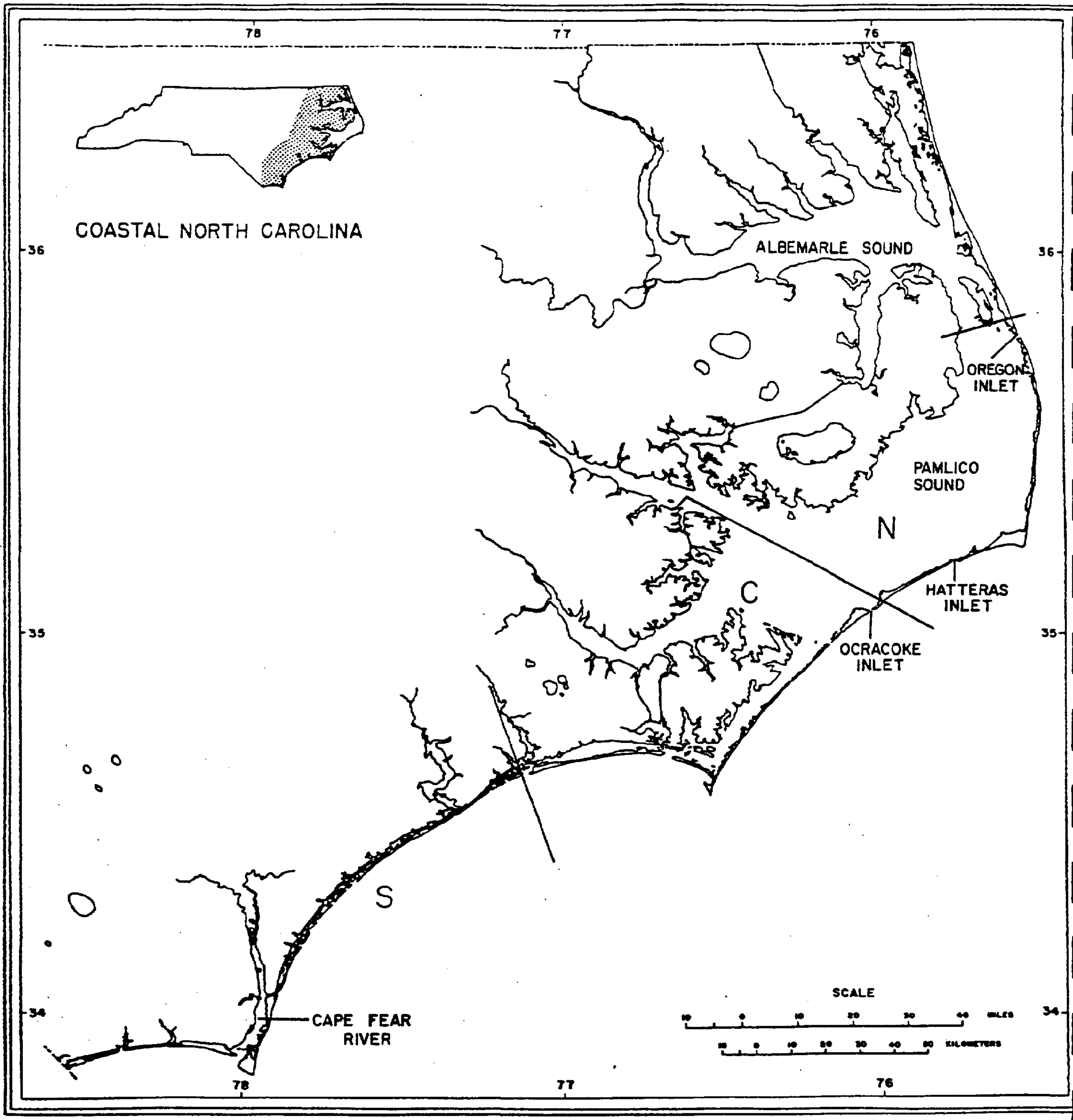

Figure 1. General sampling areas in coastal North Carolina for the juvenile finfish and crustacean investigation. N = northern area, C = central area, S = southern area.

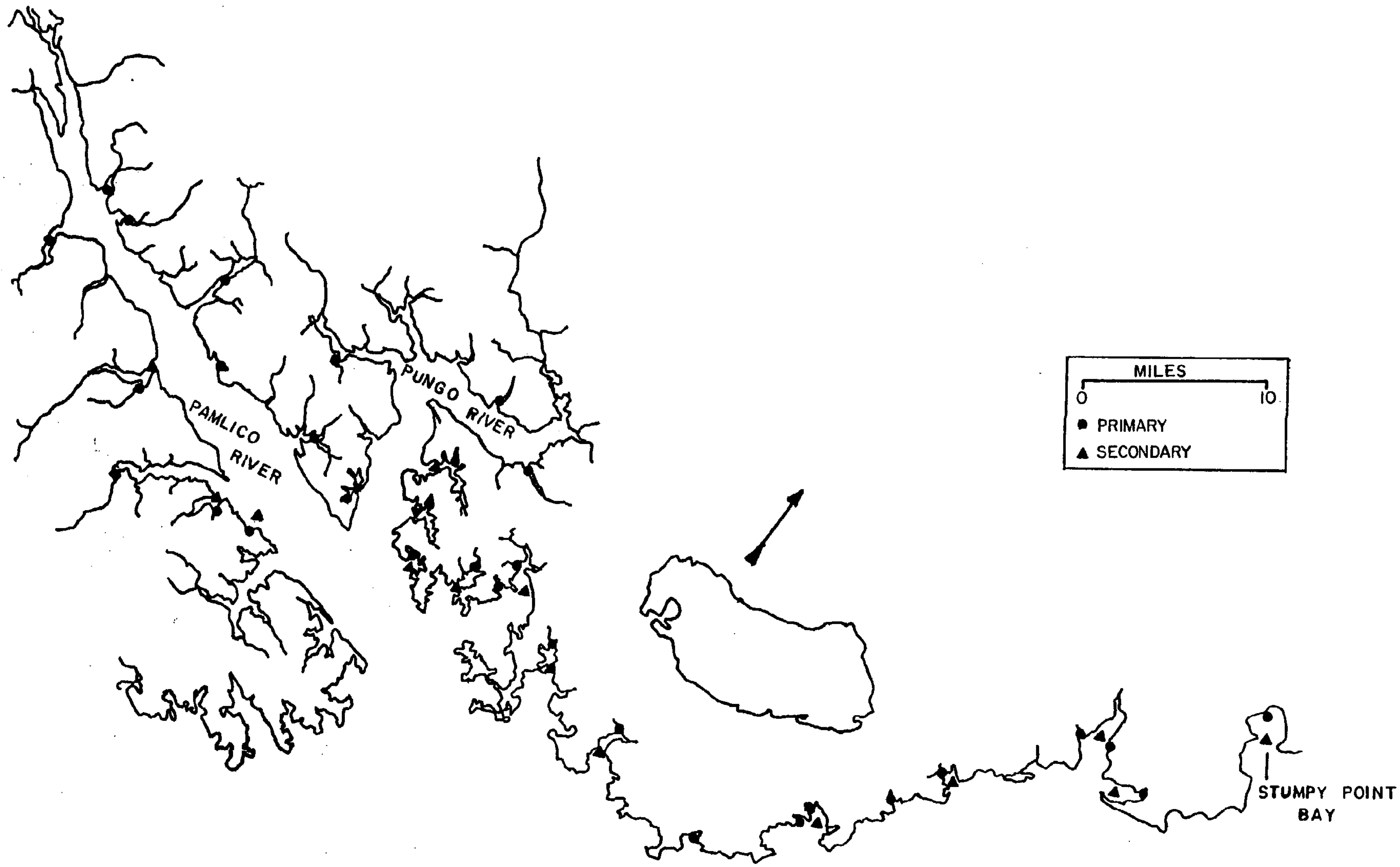

Figure 2. The northern study area with juvenile finfish and crustacean sampling stations in North Carolina.

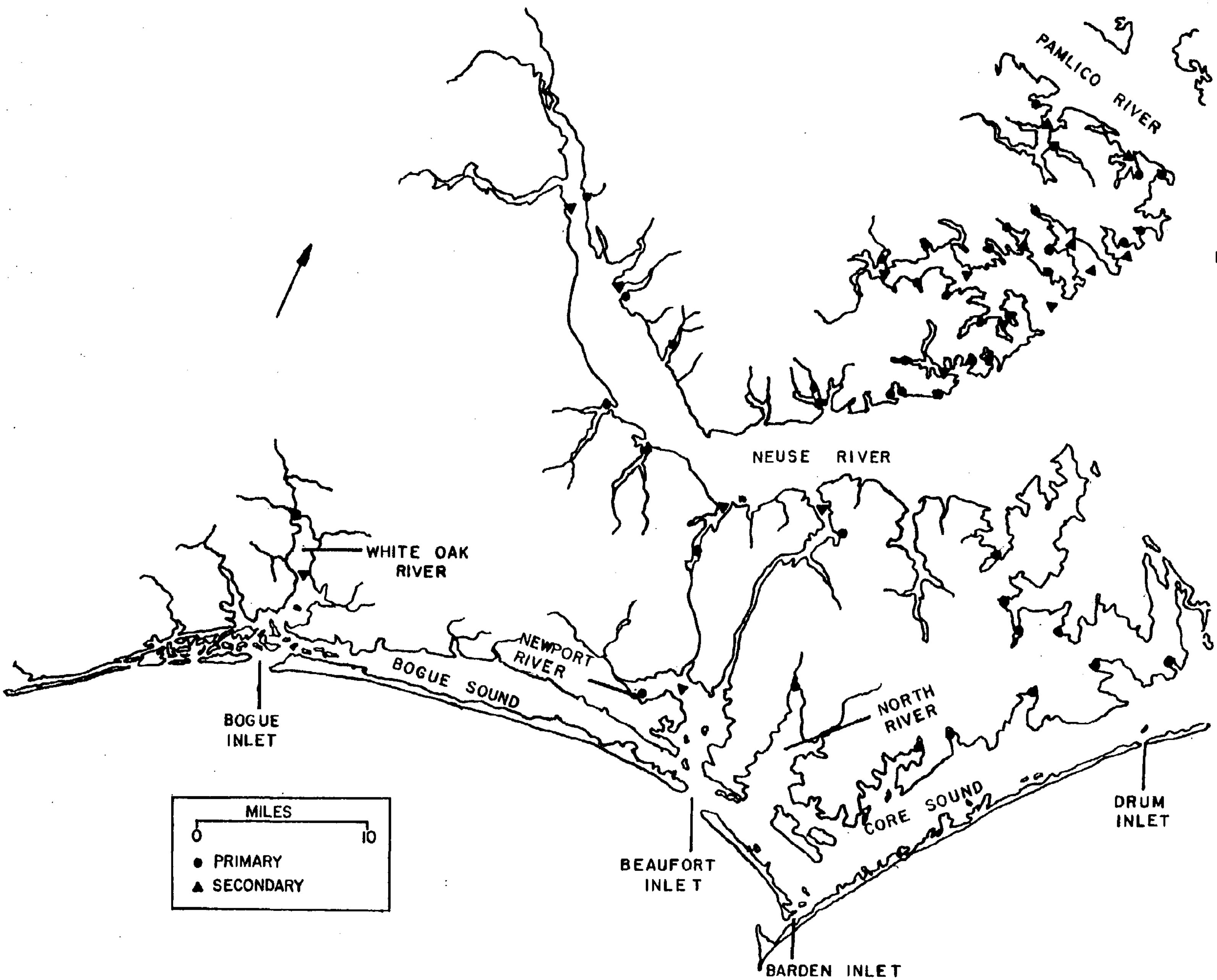

Figure 3. The central study area with juvenile finfish and crustacean sampling stations in North Carolina.

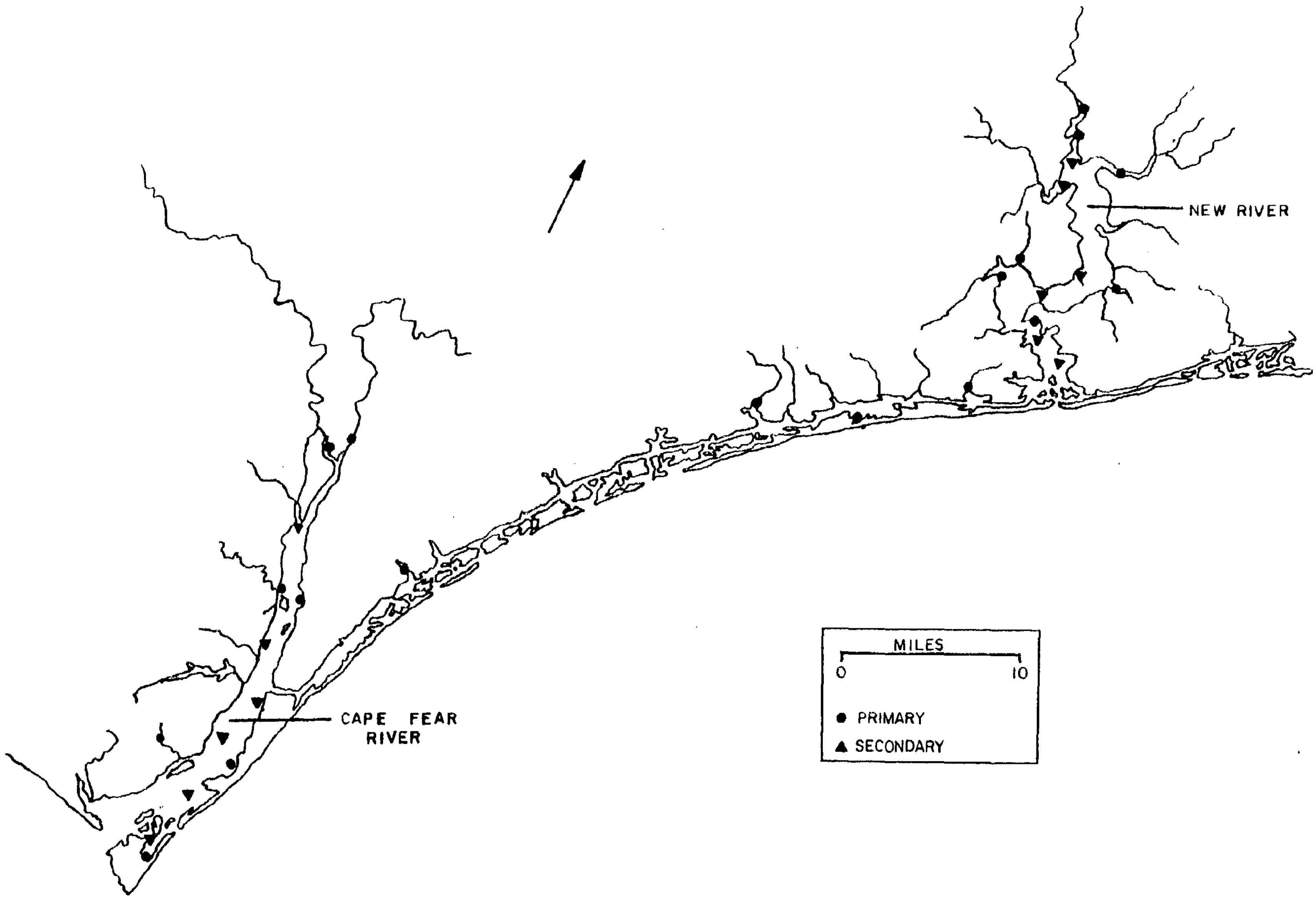

Figure 4. The southern study area with juvenile finfish and crustacean sampling stations in North Carolina.

Two major tributaries in the northern area are the Pamlico and Pungo rivers. The Pamlico River extends 63 km, while the Pungo River estuary reaches 25 km. Both rivers have salinities ranging from 0 to 20 ppt, and negigible lunar tides, which are overwhelmed by wind tides up to 0.9 m (Hobbie 1970). High marshes (*Juncus spp.*) are found sporadically along both rivers.

The central section extends from the mouth of the Pamlico River to the White Oak River (Figure 3). The major water bodies in the area include the western tributaries of Pamlico Sound, Neuse River, Core Sound, and Bogue Sound. Western Pamlico Sound and the lower Neuse River encompass 72,484 ha of estuarine waters (Spitsbergen and Wolff 1974) and are similar to the tributaries of northern Pamlico Sound in salinity and tidal characteristics.

Core Sound is a very shallow embayment, averaging 0.9 - 1.2 m in depth. It stretches 67 km from Pamlico Sound southward to Beaufort Inlet, where it meets Bogue Sound (Street and McClees 1981). Bogue Sound extends approximately 46 km westerly, averaging 0.8 m in depth (Marshall 1951). Both sounds vary from 1.9 to 5.4 km in width and contain numerous shoals. Sandy bottoms predominate the areas, often covered with eel grass (*Zostera marina*) and shoal grass (*Halodule wrightii*). Diurnal tides are generally less than 0.9 m in amplitude. Salinities in the sounds vary with locality, being higher near the four inlets (Drum, Barden, Beaufort, Bogue), but generally averaging 25 ppt or more (Street and McClees 1981). The three major tributaries of these sounds are the North, Newport, and White Oak rivers (Figure 3).

The area from Bogue Inlet to the Cape Fear River constitutes the southern region (Figure 4). The coastline of this area is fringed with numerous small, shallow lagoons interrupted by marshes and bordered with small creeks (Marshall 1951). These marshes and creeks are characterized by large amounts of smooth cordgrass (*Spartina alterniflora*), muddy bottoms, and diurnal tides of 0.9 - 1.5 m. Salinities in the area generally are above 20 ppt, except in the upper reaches of the estuaries. Numerous inlets transverse the area, dividing the coast into many water bodies (Street and McClees 1981). New River interrupts the extensive marshes, extending northerly for 86 km (Sholar 1975).

The Cape Fear River stretches 45 km from the salt boundary at Wilmington to the river mouth (Weinstein 1979). The area is characterized by high salinities that are stratified into a two layer system (Carpenter 1979). Tidal current

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The Cape Fear River stretches 45 km from the salt boundary at Wilmington to the river mouth (Weinstein 1979). The area is characterized by high salinities that are stratified into a two layer system (Carpenter 1979). Tidal current velocities are high, averaging 1.5 m/s at the river mouth during ebb tide. The Cape Fear River contains extensive salt marshes (8,900 ha) which form the largest continuous system of this type in North Carolina (U.S. Army Corps of Engineers 1977). Smooth cordgrass, black needlerush, and giant reedgrass (*S. cyanosuroides*) dominate the vegetation bordering the estuary. Weinstein (1979) estimated that the Cape Fear's tidal creeks cover 648 ha, and shoals between the channel and salt marshes form approximately 7,285 ha of potential nursery habitat for juvenile fish and crustaceans.

Sampling Gear

The primary nursery area stations (92) were sampled with a 3.9 m head rope flat trawl composed of 6.3 mm bar mesh knotted wings and body, with a 3.2 mm bar mesh knitted tail bag (¼" trawl). Secondary nursery area stations (46) were sampled with similar gear, except the head rope measured 6.4 mm and the bar mesh was 19.2 mm in the wings (3/4" trawl). The secondary nursery area trawl was originally fitted with a 19.2 mm bar mesh tail bag; however, a 6.3 mm bar mesh tail bag was installed in October, 1980 for the central area, in March, 1981 for the southern area, and in May, 1981 for the northern area. Both trawls were fitted with bottom towing doors and a tickler chain.

The primary and sceondary nursery area trawls were standardized by towing at a speed necessary to cover 68.6 m in one minute. The primary stations were pulled for one minute and the secondary stations for five minutes. The following data were recorded at each station: date, location, tow time, gear type, and surface and bottom salinities and water temperatures.

All fish and crustaceans were identified and counted, with a maximum of 60 randomly-selected individuals per species measured at each station. Species measured during October and November, 1980 were visually placed in 10 mm modal groups and exact lengths were recorded for those measured during 1981. Most fishes were measured in fork length; however, total length was taken on species without a forked tail (Atlantic croaker, summer flounder, etc.). Disk width was recorded for skates and rays. Carapace width was recorded for all crabs, in addition to sex and maturity state for blue crabs. Exact lengths were taken on blue crabs during 1981 from the northern and central areas, and 10 mm modal groups were recorded in the southern area. Shrimp were measured in total length and usually placed in 10 mm modal groups. Length frequency data were presented as moving averages of three, with frequencies rounded to a minimum value of one if specimens were captured. Species abundance data were $\log_{10}$ transformed prior to seasonal abundance analysis to decrease the effect of extreme values.

RESULTS AND DISCUSSION

Hydrographic Description

Monthly ranges of temperatures (^{o}C) and salinities (ppt) for each region are presented in Table 1. The highest water temperatures were found in July and the lowest in March for all three areas. Water temperatures during 1980 remained fairly warm through October, averaging approximately 20^{o}C. Temperatures began to increase again during late March, 1981.

Highest salinities occurred in the proximity of the Atlantic Ocean and decreased further inland. The southern area exhibited the widest salinity fluctuation, due to daily lunar tidal effects. The central area stations in Core and Bogue Sounds were also considerably influenced by lunar tides. The Outer Banks and Pamlico Sound buffer lunar tides for most of the central area's stations and for all of the northern area's stations. Salinities in the northern and central areas were greatly influenced by the natural discharge of the Neuse and Pamlico rivers. The lowest salinities in each area were usually recorded upstream in those rivers. The lowest seasonal salinities were recorded during November, 1980. Salinities continued to rise throughout winter, peaking in March, 1981 for stations in the northern and central areas. Salinities remained extremely high in the tributaries of Pamlico Sound throughout spring, due to unusually low amounts of rainfall. Salinities appeared to be the highest ever documented for the March-May period in tributaries of western and northern Pamlico Sound.

Finfish

Total Catch Composition

Numerous fishes spawn in the ocean and enter estuaries during their early life stages. Many authors have noted large number of juvenile fish utilizing

Table 1. Monthly extremes of salinities (ppt) and temperatures (^{o}C) in North Carolina estuarine waters, October-November, 1980 and March-July, 1981. (N=northern area, C=central area, S=southern area.)

	Salinity Area			Temperature Area		
	N	C	S	N	C	S
Oct	6.0-17.0	14.0-33.0	4.0-35.0	18.0-22.0	16.0-23.0	16.0-23.0
Nov	4.5-22.6	3.0-29.0	4.0-32.0	8.5-14.0	8.0-18.0	11.0-14.5
Mar	10.5-24.0	1.0-33.0	0.0-30.0	7.1-15.7	2.9-18.0	10.0-16.0
Apr	2.0-18.5	2.0-29.0	2.0-33.0	16.0-22.0	15.9-22.0	17.0-25.0
May	2.0-19.0	10.3-33.1	0.0-30.0	15.4-28.0	17.0-25.4	18.0-23.0
Jun	6.0-20.0	6.5-30.6	0.0-30.0	25.0-33.0	16.1-32.6	28.5-32.0
Jul	1.0-21.0	6.5-20.6	0.0-32.0	27.0-32.0	27.7-32.3	28.0-35.0

shallow estuarine tributaries, a few of which are Dahlberg and Odum (1970), Cain and Dean (1976) and Marshall (1976). The present study captured 88 species during October and November, 1980 and March through July, 1981 (Table 2). Similar North Carolina coast estuarine studies produced 86 to 107 fish species between 1978 and 1980 (Carpenter 1979; Ross 1980, in press). The slightly higher species number in 1978 (107) was due to the inclusion of twelve Outer Banks stations which produced several stenohaline marine species, and the addition of seine stations which resulted in the capture of more shoreline-associated species. Species composition has not changed measurably during the past four years.

The sciaenid family represented by 11 species, composed the majority (72%) of the finfish catch. *Leiostomus xanthurus* (spot), *Micropogonias undulatus* (Atlantic croaker), *Bairdiella chrysoura* (silver perch), and *Cynoscion regalis* (weakfish) were the most abundant sciaenids. Other well-represented families included engraulids (23%), consisting almost entirely of *Anchoa mitchilli* (bay anchovy), and clupeids (3%), composed of *Brevoortia tyrannus* (Atlantic menhaden) and alosids. Spot was the most abundant fish, comprising 61% of the total juveniles captured (Table 3). The percentage of spot in the total catch in 1981 was considerably higher than the 48% and 41% found during 1979 and 1980 (Ross 1980, in press).

Bay anchovies, second in numerical abundance, composed almost 25% of the total catch in 1981. Ross (1980, in press) found similar percentages in previous surveys. Atlantic croaker was the third most abundant fish, composing 5% of the total number. This percentage was lower than the 10% of the 1979 catch and the 23% of the 1980 catch (Ross 1980, in press). Two other sciaenids, silver perch and weakfish, were also common, ranking fourth and sixth in abundance, respectively. Both species were considerably more abundant in trawl catches during 1981 than in 1980 or 1979, when each composed 3% of the total numbers caught. Some increase in numbers may reflect a more efficient sampling gear in deeper waters. Silver perch only composed 0.7% of the total catch in 1979 and 0.8% in 1980, and weakfish, only 0.1% and 0.3%. Menhaden represented 3% of the total catch (fifth in abundance), compared to 7% in 1979 and 3% in 1980 (Ross 1980, in press).

The present juvenile survey compares favorably with similar studies along the Atlantic and Gulf of Mexico coasts, where sciaenids, engraulids, and clupeids were the most abundant taxa in estuarine waters (Dahlberg 1972, Christmas and Waller 1973,

Table 2. Total numbers and size range[1] of fish collected by flat trawls in North Carolina estuarine monitoring for October 1980 - July 1981.

	Areas											
	Northern				Central				Southern			
	1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl	
Species	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range
Carcharhinidae												
Rhizoprionodon terraenovae (Atlantic sharpnose shark)											1	331
Dasyatidae												
Dasyatis americana (southern stingray)											1	269
Dasyatis sabina (Atlantic stingray)	1	990			1	-					1	391
Lepisosteidae												
Lepisosteus osseus (longnose gar)	8	880										
Elopidae												
Elops saurus (ladyfish)	4	36-146			26	25-418			26	25-148		
Anguillidae												
Anguilla rostrata (American eel)	44	51-535	16	125-460	144	53-520	18	212-705	18	53-397	7	174-274
Ophichthidae												
Myrophis punctatus (speckled worm eel)									1	235		

Table 2. (continued).

Species	Northern 1/4" trawl N	Northern 1/4" trawl Size range	Northern 3/4" trawl N	Northern 3/4" trawl Size range	Central 1/4" trawl N	Central 1/4" trawl Size range	Central 3/4" trawl N	Central 3/4" trawl Size range	Southern 1/4" trawl N	Southern 1/4" trawl Size range	Southern 3/4" trawl N	Southern 3/4" trawl Size range
Clupeidae												
Alosa aestivalis (blueback herring)	7	35-78	10	49-222								
A. mediocris (hickory shad)							1	138				
A. pseudoharengus (alewife)	3	73-101	3	77-125	1	72						
A. sapidissima (American shad)									1	40		
Brevoortia tyrannus (Atlantic menhaden)	3,304	18-135	526	32-244	1,116	21-146	694	30-183	3,699	23-140	989	31-158
Dorosoma cepedianum (gizzard shad)	3	75-261	10	135-305	2	124-241			2	85-104		
Engraulidae												
Anchoa hepsetus (striped anchovy)	35	42-89	54	48-74	1	59	2	76-100			4	45-71
A. mitchilli (bay anchovy)	18,535	16-86	10,435	21-92	22,335	17-106	15,631	22-105	4,300	19-93	6,134	26-86
Synodonitidae												
Synodus foetens (inshore lizardfish)					3	38-107			33	33-205	8	72-157
Cyprinidae												
Notropis hudsonius (spottail shinner)	6	15-25										

Table 2. (continued).

	Areas											
	Northern				Central				Southern			
	1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl	
Species	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range
Notropis spp.	6	15-25										
Ictaluridae												
Ictalurus catus (white catfish)	1	225							1	165	2	182-425
Batrachoididae												
Opsanus tau (oyster toadfish)					2	25-105	2	196-201	4	55-135	4	73-176
Gobiesocidae												
Gobiesox strumosus					1	46						
Gadidae												
Urophycis floridana (southern hake)							5	75-147				
U. regia (spotted hake)			10	147-181	2	64-132	45	82-159			58	72-179
Cyprinodontidae												
Fundulus heteroclitus (mummichog)									1	52		
Fundulus spp.	1	52										
Lucania parva (rainwater killifish)	230	16-50										
Atherinidae												
Membras martinica (rough silverside)	1	111										
Menidia beryllina (tidewater silverside)	6	45-105			5	35-63						

Table 2. (continued).

Species	Northern 1/4" trawl N	Northern 1/4" trawl Size range	Northern 3/4" trawl N	Northern 3/4" trawl Size range	Central 1/4" trawl N	Central 1/4" trawl Size range	Central 3/4" trawl N	Central 3/4" trawl Size range	Southern 1/4" trawl N	Southern 1/4" trawl Size range	Southern 3/4" trawl N	Southern 3/4" trawl Size range
M. menidia (Atlantic silverside)					21	59-113			4	61-86		
Syngnathidae												
Syngnathus floridae (dusky pipefish)					3	83-236	2	168-194				
S. fuscus (northern pipefish)	5	82-164			2	129-147	1	173				
S. louisianae (chain pipefish)											7	106-348
Percichthyidae												
Morone americana (white perch)	48	65-225			1	230	1	188				
Serranidae												
Mycteroperca microlepis (gag)							1	175	1	41		
Centrarchidae												
Centrarchus macropterus (flier)	1	29										
Lepomis gibbosus (pumpkinseed)	16	73-185			6	64-195						
L. macrochirus (bluegill)											1	195

Table 2. (continued).

	Areas											
	Northern				Central				Southern			
	1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl	
Species	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range
Percidae												
Perca flavescens (yellow perch)					1	175						
Pomatomidae												
Pomatomus saltatrix (bluefish)	6	52-103	20	59-155	5	66-94	3	96-227	4	63-72	7	21-227
Carangidae												
Caranx hippos (crevalle jack)	7	34-72	19	32-128	52	24-43	3	34-52	11	27-41	3	21-32
Chloroscombrus chrysurus (Atlantic bumper)					2	50-64	5	32-92				
Selene vomer (lookdown)			1	75			1	32	3	37-61	6	43-63
Lutjanidae												
Lutjanus griseus (gray snapper)									3	65-115	1	135
L. synagris (lane snapper)							1	130	1	55		
Gerreidae												
Diapterus auratus (Irish pompano)									9	34-56		
Eucinostomus argenteus (spotfin mojarra)					19	45-65						

Table 2. (continued).

Species	Northern 1/4" trawl N	Northern 1/4" trawl Size range	Northern 3/4" trawl N	Northern 3/4" trawl Size range	Central 1/4" trawl N	Central 1/4" trawl Size range	Central 3/4" trawl N	Central 3/4" trawl Size range	Southern 1/4" trawl N	Southern 1/4" trawl Size range	Southern 3/4" trawl N	Southern 3/4" trawl Size range
E. gula (silver jenny)	7	45-55							58	36-75	52	55-105
Haemulidae												
Orthopristis chrysoptera (pigfish)					14	23-165	4	105-204	5	20-135		
Sparidae												
Archosargus probatocephalus (sheepshead)									2	95-135		
Lagodon rhomboides (pinfish)	199	21-125	6	29-85	350	18-180	40	56-165	2,043	16-145	462	21-146
Sciaenidae												
Bairdiella chrysoura (silver perch)	1,863	8-126	5,299	12-258	3,609	11-205	199	24-172	30	51-141	96	111-162
Cynoscion nebulosus (spotted seatrout)	22	22-58	3	52-56			1	102			1	175
C. regalis (weakfish)	198	14-108	4,795	23-272	354	18-182	2,101	25-257			18	153-228
C. nothus (silver seatrout)									43	30-73	124	31-145
Leiostomus xanthurus (spot)	39,391	17-195	23,920	31-195	42,614	17-219	50,009	18-214	40,097	15-183	13,583	18-199
Menticirrhus americanus (southern kingfish)							1	47				
M. saxatilis (northern kingfish)											20	41-101

Table 22. (continued).

Species	Northern 1/4" trawl N	Northern 1/4" trawl Size range	Northern 3/4" trawl N	Northern 3/4" trawl Size range	Central 1/4" trawl N	Central 1/4" trawl Size range	Central 3/4" trawl N	Central 3/4" trawl Size range	Southern 1/4" trawl N	Southern 1/4" trawl Size range	Southern 3/4" trawl N	Southern 3/4" trawl Size range
Micropogonias undulatus (Atlantic croaker)	3,425	15-240	3,882	29-283	1,489	9-194	3,676	26-240	1,279	15-158	4,803	12-230
Pogonias cromis (black drum)									2	225		
Sciaenops ocellata (red drum)			2	23-42	5	51-268	17	36-76				
Stellifer lanceolatus (star drum)											7	75
Ephippidae												
Chaetodipterus faber (Atlantic spadefish)	2	38-65	3	48-56	3	38-54	11	52-95	1	129	3	27-33
Mugilidae												
Mugil cephalus (striped mullet)	6	122-205	6	90-233	55	23-408	28	115-322	15	31-289	26	31-155
Sphyraenidae												
Sphyraena spp.											1	31
Blennidae												
Hypsoblennius hentzi (feather blenny)											1	75
H. ionthas (freckled blenny)					1	39			1	45		
Gobiidae												
Gobionellus boleosoma (darter goby)									12	15-52		

Table 2. (continued).

Species	Northern				Central				Southern			
	1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl	
	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range
G. hastatus (sharptail goby)									2	65-105		
Gobiosoma bosci (naked goby)	139	15-51			109	10-53			27	22-45		
Microgobius thalassinus (green goby)	133	21-51			84	21-47	1	30				
Trichiuridae												
Trichiurus lepturus (Atlantic cutlassfish)							1	476			15	186-691
Scombridae												
Scomberomorus maculatus (Spanish mackerel)			2	84-105								
Stromateidae												
Peprilus alepidotus (harvestfish)	7	28-48	114	28-95	10	23-55	26	34-90	1	73	1	95
P. triacanthus (butterfish)	1	48	1	68			6	32-54	7	41-75	19	24-101
Triglidae												
Prionotus evolans (striped searobin)			2	42-51	1	151	4	42-66	5	37-81	24	25-151
P. scitulus (leopard searobin)							2	85				
P. tribulus (bighead searobin)					1	43	13	35-100				

Table 2. (continued).

Species	Northern 1/4" trawl N	Northern 1/4" trawl Size range	Northern 3/4" trawl N	Northern 3/4" trawl Size range	Central 1/4" trawl N	Central 1/4" trawl Size range	Central 3/4" trawl N	Central 3/4" trawl Size range	Southern 1/4" trawl N	Southern 1/4" trawl Size range	Southern 3/4" trawl N	Southern 3/4" trawl Size range
Bothidae												
Ancylopsetta quadrocellata (ocellated flounder)					1	139	2	101-105			6	89-105
Citharichthys spilopterus (bay whiff)	3	74-86			23	42-115	14	99-130	19	35-88	15	41-105
Etropus crossotus (fringed flounder)							1	95	1	95	31	53-115
Paralichthys dentatus (summer flounder)	1	300	22	86-288	10	21-161	10	122-291	36	28-125	8	37-130
P. lethostigma (southern flounder)	330	12-292	75	44-210	422	15-405	125	32-341	324	12-146	21	35-245
Scophthalmus aquosus (windowpane)							2	89-101			30	52-90
Soleidae												
Trinectes maculatus (hogchoker)	119	25-143	67	54-145	273	11-146	147	27-163	21	41-78	15	51-82
Cynoglossidae												
Symphurus plagiusa (blackcheek tonguefish)			2	91-104	9	31-79	15	65-150	32	35-88	24	26-134
Balistidae												
Monacanthus hispidus (planehead filefish)							1	105			15	36-115

Table 2. (continued).

	Areas											
	Northern				Central				Southern			
	1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl	
Species	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range
Tetraodontidae												
Sphoeroides maculatus (northern puffer)									1	17		
Total no. species		43				57				61		

[1]Sizes reported in fork length or total length (mm) except stingrays, which are measured in disk width.

Table 3. Total numbers and percent of total catch for the most commonly occurring juvenile finfish captured by trawl (all stations combined) in North Carolina estuarine waters, October-November, 1980 and March-July, 1981.

Species	Total number	Percent of total fish caught
**Leiostomus xanthurus*	209,584	61.46
Anchoa mitchilli	77,370	22.69
**Micropogonias undulatus*	17,244	5.06
Bairdiella chrysoura	11,097	3.25
**Brevoortia tyrannus*	10,338	3.03
**Cynoscion regalis*	7,465	2.19
Lagodon rhomboides	3,168	0.93
**Paralichthys lethostigma*	1,297	0.38
Trinectes maculatus	642	0.19
Gobiosoma bosci	275	0.08
**Anguilla rostrata*	242	0.07
Lucania parva	230	0.07
Microgobius thalassinus	217	0.06
Cynoscion nothus	167	0.05
**Peprilus alepidotus*	159	0.05
**Mugil cephalus*	136	0.04
Eucinostomus gula	117	0.03
Urophycis regia	116	0.03
Anchoa hepsetus	96	0.03
Caranx hippos	95	0.03
**Paralichthys dentatus*	87	0.02

*Commercially important species

Shealy et al. 1974). The relatively shallow estuarine waters of North Carolina offer habitat for numerous species; however, a few particular species, such as spot, croaker, bay anchovies, weakfish, silver perch, and menhaden dominate the areas sampled. Species numerically dominating estuarine waters are migratory, usually returning to the ocean or more open waters to spawn. Weinstein (1979) noted the importance of these species to the ecology of the shallow marsh habitat in southern North Carolina. He observed that if the transient species of the shallow marsh community were removed, the remaining year-round inhabitants would form a community noted for the scarcity of its taxa.

Interregion Comparisons

The largest number of species (61) was captured in the southern area. Previous investigations also found more species in the southern area relative to other state regions (Carpenter 1979; Ross 1980, in press). Carpenter (1979) attributed the high number of species in the southern region to the influx of stenohaline marine species and to the occurrence of more warm water species. The relatively high exchange of water in the area's estuaries with the Atlantic Ocean provides fish with easily accessible habitat, characterized by desirable higher salinities. The lack of such habitat in the northern area may account for the death of stenohaline marine species in that area's collections.

The most abundant species (spot, bay anchovy, Atlantic croaker) were similar in percent composition among regions (Table 4). Spot and bay anchovies composed the majority of the juvenile catch by number and appeared ubiquitous. Copeland and Birkhead (1972) and Weinstein (1979) found spot, croaker, and bay anchovies to dominate catches in the southern area. Spitsbergen and Wolff (1974) and Purvis (1976) found similar species compositions in the central and northern areas. Spot were much more common and caught in higher quantities in the central and northern areas during 1981 than during any other similar Division investigation. Spot composed 63% and 54% of the total catch in each area, compared to 35% and 40% during 1979 and 1980 (Ross 1980, in press). Purvis (1976) found spot accounted for 55% of the commercially-important individuals captured in a juvenile survey during 1974-75 in the northern region. Spot represented 79% of the commercially-important species captured in 1981. In the central area during 1972-73, Spitsbergen and Wolff (1974) found that spot composed 45% of the commercially-important fish captured, compared to 90% of the catch in 1981.

Table 4. Total numbers and percent of total catch by area for selected species captured by trawl in North Carolina estuarine waters, October-November, 1980 and March-July, 1981.

	Areas					
	Northern		Central		Southern	
Species	N	Percent of area's total number	N	Percent of area's total number	N	Percent of area's total number
**Leiostomus xanthurus*	63,111	53.9	92,623	63.4	53,680	68.0
Anchoa mitchilli	28,970	24.7	37,966	26.0	10,434	13.2
**Micropogonias undulatus*	7,307	6.2	5,165	3.5	6,082	7.7
Bairdiella chrysoura	7,162	6.1	3,808	2.6	90	0.1
**Cynoscion regalis*	4,993	4.2	2,455	1.7	18	0.1
**Brevoortia tyrannus*	3,830	3.3	1,810	1.2	4,688	5.9
**Paralichthys lethostigma*	405	0.3	547	0.4	345	0.4
Lagodon rhomboides	205	0.2	390	0.3	2,505	3.2
Trinectes maculatus	186	0.2	420	0.3	36	0.1
Total Number	117,429		146,061		78,873	

*Commercially important species

Differences in annual species composition between regions were also noticeable with Atlantic croaker. In 1981 croaker were less abundant in juvenile trawl catches than during any other similar investigation. Croaker composed only 3% of the central region's catch in 1981, compared to 8% in 1979 and 29% in 1980 (Ross 1980, in press). Spitsbergen and Wolff (1974) found croaker accounting for 29% of the commercially-important species in the central area during 1972-73. In 1981, croaker represented only 5% of the commercial species captured in the region. Croaker accounted for only 6% of the northern area's total catch during 1981, compared to 15% and 24% found in 1979 and 1980 (Ross 1980, in press). In the southern area, Atlantic croaker composed 8% of the total catch. Weinstein (1979) reported that croaker were virtually absent in the tidal creeks of the Cape Fear region, while Copeland and Birkhead (1972) listed croaker as one of the more abundant species in the lower Cape Fear.

Juvenile Atlantic menhaden were common in all three regions. Previous investigators noted the species' abundance in catches (Carpenter 1979; Ross 1980, in press). In 1981 menhaden represented 1% to 6% of the total catch in each region, with the highest occurrence found in the southern area. Purvis (1976) and Spitsbergen and Wolff (1974) found that juvenile menhaden represented somewhat higher percentages in previous surveys of the northern and central regions; however, studies in 1979 and 1980 found menhaden abundances similar to this study (Ross 1980, in press).

Other distinct differences in relative abundance of species between regions were noted with weakfish, silver perch, and pinfish. Weakfish were more common in catches from the northern and central regions, comprising up to 4% of the total catch. Juvenile weakfish catches in the southern area were insignificant in 1981, a phenomenon also reported by Carpenter (1979) and Ross (1980, in press). In contrast, Hobbie (1971) and Copeland and Birkhead (1972) reported weakfish as the most abundant juvenile finfish in the lower Cape Fear. Weakfish composed a major part of the total juvenile catch in the northern and central areas, ranking fifth in abundance in each region and representing 4% (northern) and 2% (central) of the catch in each region. These percentages are somewhat higher than those found during 1979 (0.3%) and 1980 (0.5%) (Ross 1980, in press). The increases were at least partially due to the addition of a smaller mesh tail bag to the secondary areas' sampling gear. Silver perch also occurred in low numbers in the southern area and relatively high numbers in the northern and central regions. Silver perch were more abundant in trawl catches during 1981 than in 1979 and 1980, composing 6% of the northern area's and 3% of the central area's total catch. The inverse situation holds true for pinfish, where numbers were much higher in the southern area than either the northern or central areas.

Major Species

Seven species of fish are discussed in detail. These species were chosen because of their economic importance and high abundance.

Brevoortia tyrannus (Latrobe)-Atlantic menhaden

The Atlantic menhaden yield the highest harvest volume of any single fish species in North Carolina and the entire Atlantic coast. It is utilized for fish meal, oils, and fish solubles. Atlantic menhaden range from Nova Scotia to Florida, spawning in some part of their range during almost every month (Hildebrand 1963, Higham and Nicholson 1964). Off North Carolina, menhaden spawn during early winter through early spring (Lewis and Mann 1971). After hatching offshore, larvae are transported to estuarine waters by currents and tides. Once in estuarine waters, larval menhaden move upstream into lower salinities to metamorphose into juveniles (June and Chamberlain 1959, Wilkens and Lewis 1971). Metamorphosis usually begins at 30 mm FL and is generally complete as the fish approach 40 mm FL (Hildebrand 1963). Juveniles grow rapidly (20-30 mm per month) while in estuaries, where the fish generally remain until fall. Juvenile migration towards open water is usually completed by late fall, with most of the young moving into the ocean and some over-wintering in the estuaries (Kinnear 1973). A large menhaden purse-seine fishery exists in North Carolina primarily exploiting age 1 and 2 menhaden (Nicholson 1972). Landings during 1981 were 140,350 mt (K. B. West, pers. comm.). The fishery also exploits migrating young-of-the-year during the late fall.

Atlantic menhaden was the most abundant clupeid captured (10,338 individuals). Menhaden were present in the estuaries throughout the sampling period, except during November in the southern area (Figure 5). Peak numbers of juvenile menhaden were observed in spring. New recruits were first captured in all three regions during March, at a size range of 25-48 mm FL (Figure 6). Recruitment began some time earlier as indicated by the large size of juveniles. Recruitment extended through

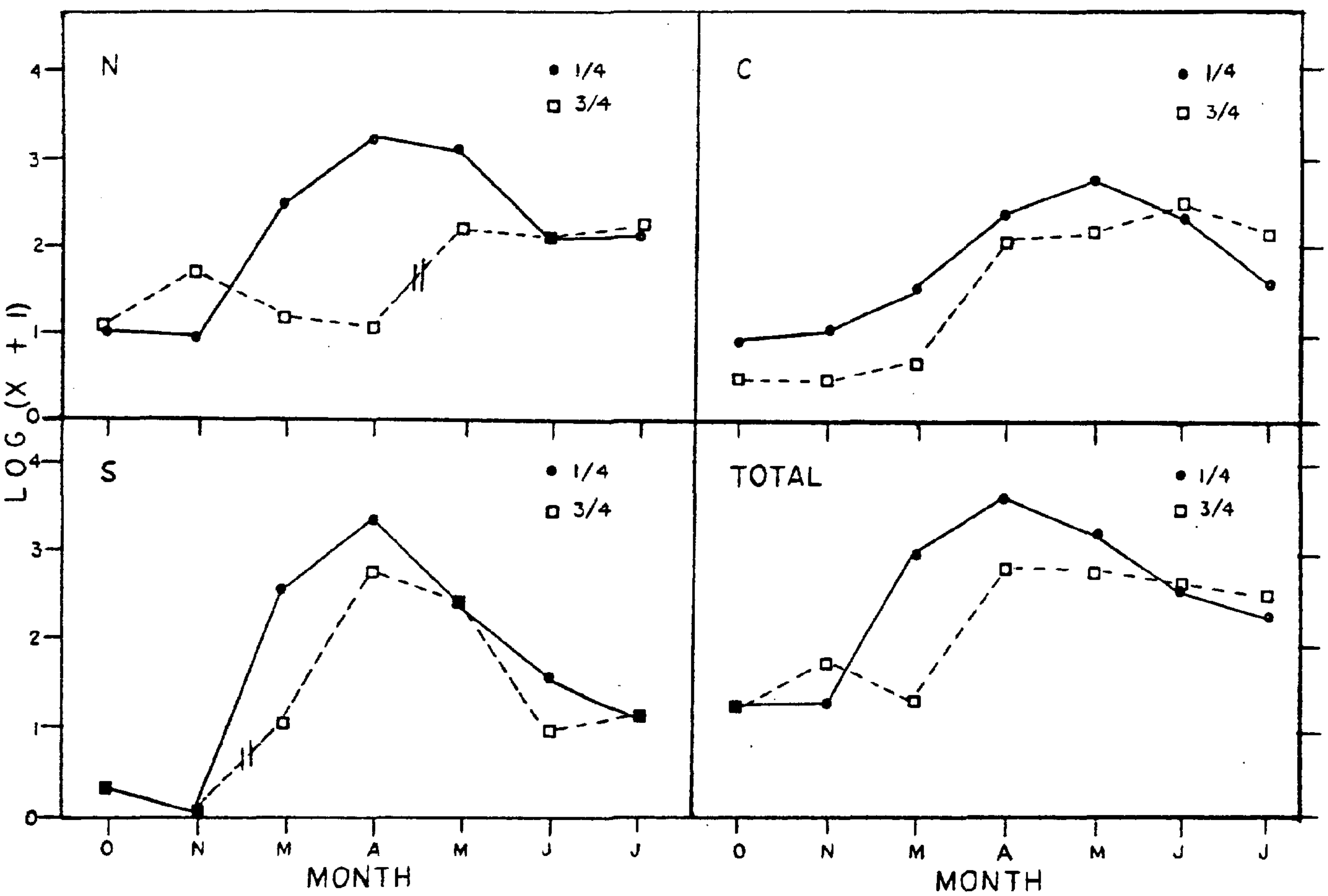

Figure 5. Seasonal abundance of *Brevoortia tyrannus* in primary (1/4") and secondary (3/4") trawl stations in North Carolina during October and November, 1980 and March - July, 1981. N=northern area, C=central area, S=southern area. Addition of 1/4" mesh tail bag to 3/4" trawl is denoted by "//".

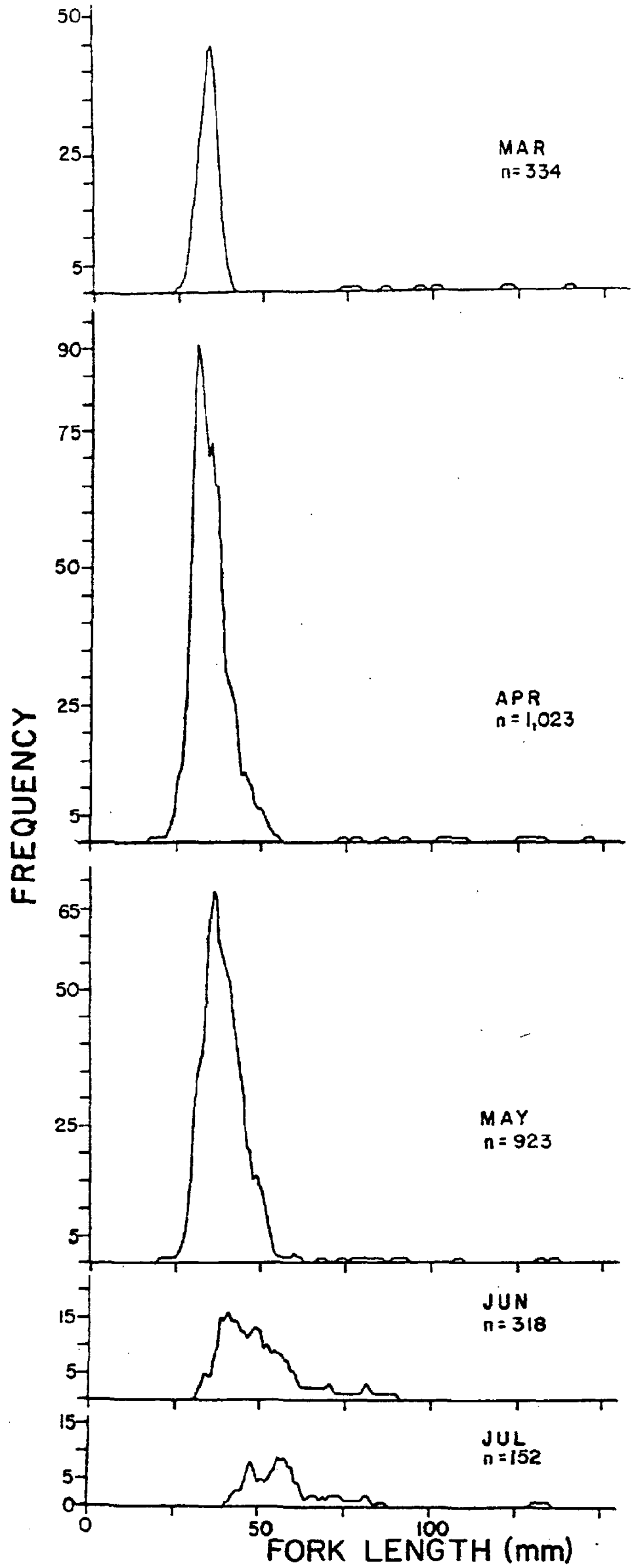

Figure 6. Length frequencies of *Brevoortia tyrannus* captured in primary stations in North Carolina (March-July, 1981).

spring, for small fish (less than 25 mm FL) were caught through May. Previous investigators have found extended recruitment periods, beginning as early as November and extending as late as June. Lewis and Mann (1971) and Wilkens and Lewis (1971) found larvel menhaden recruited into North Carolina waters from November through May, with large peaks occurring from January through March. Spitsbergen and Wolff (1974), Purvis (1976), and Wolff (1976) found that recruitment into Pamlico Sound began in February and extended into late spring/ early summer according to length frequency data. Weinstein (1979) first captured young menhaden during March in the Cape Fear River.

Peak juvenile menhaden abundance was observed during April in the shallow waters of the northern and southern areas, and during May in the central region. Relatively high numbers of small menhaden (25-60 mm FL) were also captured in the secondary areas during April in the central and southern regions. Weinstein also noticed that menhaden utilized the open waters of the Cape Fear River soon after juvenile recruitment. He found that juvenile menhaden preferred the main-stem of the river as nursery habitat and attributed the phenomenon to menhaden's feeding preference for zooplankton. As the season progressed, numbers decreased in the shallow areas of all three regions, but more rapidly in the southern area. Corresponding with decreases in juvenile abundance of the shallow areas were increases in the open, deeper waters of the northern and central regions. The decreases were apparently due to menhaden migration out of the primary habitat waters. Juvenile abundance data from secondary stations in the southern area indicated that menhaden move rapidly from tidal creeks to open waters, and were not nearly as abundant in the region by July. Menhaden were least abundant at all stations in the fall, when most juveniles had migrated out of nursery areas into the sounds and ocean.

At least two menhaden year classes utilized both the upper tributaries and open waters during March through July (Figures 6 and 7). In addition to new recruits, menhaden greater than 75 mm FL were also captured in March and April. Menhaden range between 50 and 165 mm FL when they form their first annulus and growth differentiation among individuals in a year class results in tremendous size ranges for menhaden of the same age (Kroger et al. 1974). The larger individuals found in March and April were probably small age 1 fish that over-wintered in the estuaries or later-spawned northern menhaden that migrated into

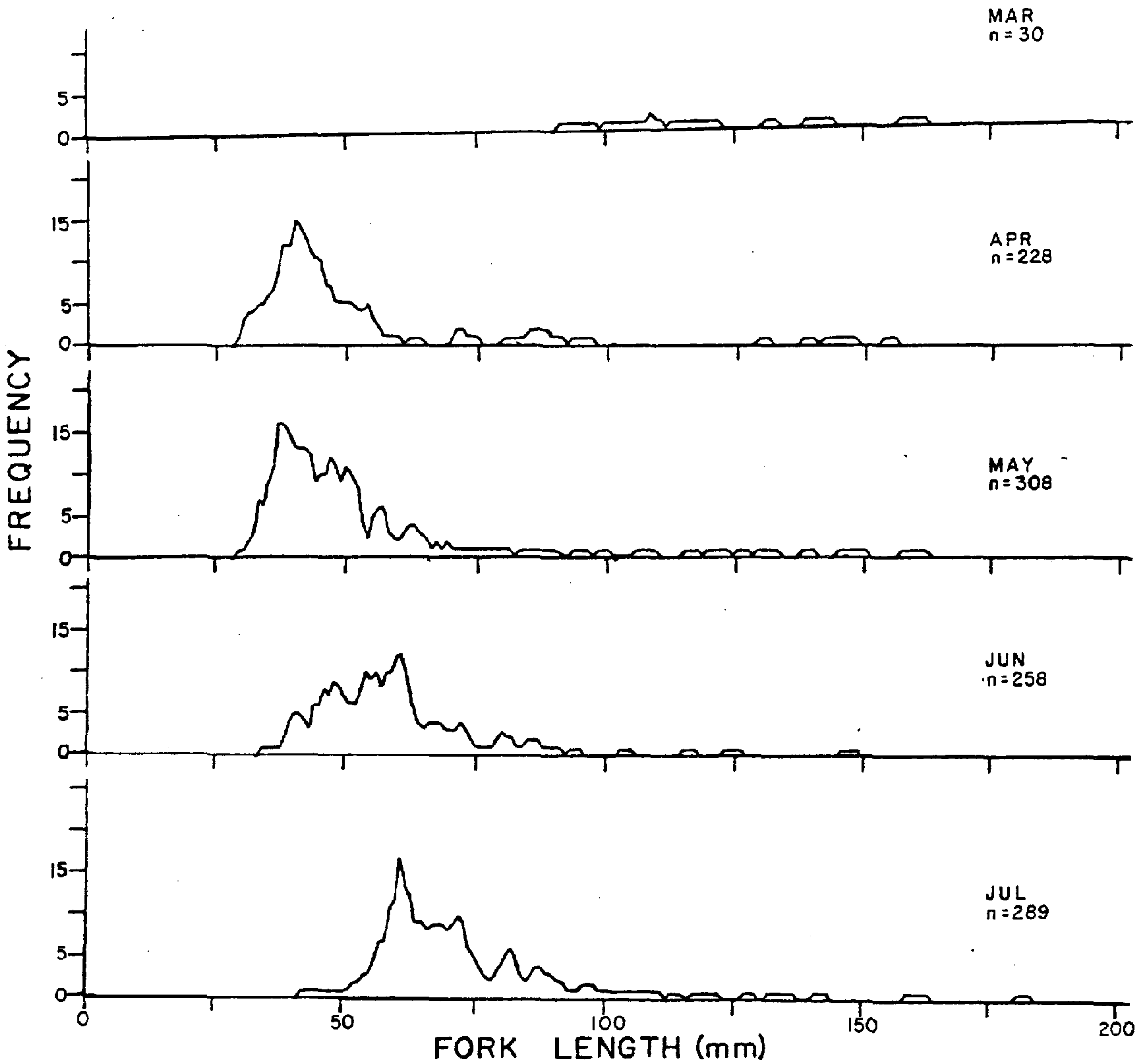

Figure 7. Length frequencies of *Brevoortia tyrannus* captured in secondary stations in North Carolina (March-July, 1981).

North Carolina estuaries. After April,separation of year classes by length frequency modes was difficult, due to mixing of faster growing young-of-the-year and smaller yearlings. Previous length frequency data also indicated at least two year classes present in the tributaries of Pamlico Sound, mainly during winter through spring (Williams and Deubler 1978a, Spitsbergen and Wolff 1974, Purvis 1976). General estimates of young-of-the-year mehnaden growth approximated by length frequency modes are presented in Table 5.

Anchoa mitchilli (Valenciennes)-Bay anchovy

Although many finfish species are not commercially important, they potentially serve an important role in the transfer of energy within the estuarine system (Subrahmanyan and Drake 1975). One such species is the bay anchovy, which feeds on various types of zooplankton and in turn is fed upon by many predacious estuarine fish. Bay anchovies appear abundant throughout their range of Massachusetts to Texas (Hildebrand 1963). Perret et al. (1971) stated that this species probably has the greatest biomass of any fish in the south Atlantic and Gulf of Mexico estuaries. Bay anchovies spawn nearshore in the Atlantic Ocean and Gulf of Mexico and also in estuaries and sounds throughout their range (Kuntz 1914, Hildebrand and Cable 1930). The species has a prolonged spawning season, lasting from March through December (Hildebrand and Schroeder 1928, Kilby 1955). Spawning in North Carolina occurs from late April to early September, with peak activity in July (Kuntz 1914, Hildebrand and Cable 1930). Very little specific information exists on juvenile movement into and out of estuaries. Gunter (1945) and Christmas and Waller (1973) documented offshore movement of bay anchovies in the Gulf of Mexico during winter.

The bay anchovy was the second most abundant species captured (77,370 individuals), representing almost 23% of the total catch. Bay anchovies were captured consistently during the sampling period, but were most abundant in early spring (Figure 8). Relatively low numbers in the secondary stations during fall in the southern region and during fall and early spring in the northern region could be partially attributed to sampling gears that were selective for larger fish. Previous studies in North Carolina have also found bay anchovies to be one of the most abundant and ubiquitious fish inhabiting estuarine waters (Carpenter 1979; Ross 1980, in press).

Table 5. Length data for age 0 year class individuals of selected species in North Carolina estuarine waters, all station collections combined by area.* (N=northern area, C=central area, S=southern area.)

	March			April			May			June			July		
Species	N	C	S	N	C	S	N	C	S	N	C	S	N	C	S
*Leiostomus xanthurus**															
Mean length	26.3	27.8	27.4	38.7	41.4	35.5	44.2	47.1	39.2	55.4	58.0	43.4	70.9	71.8	61.
Range	17-39	17-40	15-41	19-68	18-65	20-69	21-89	27-79	27-73	36-89	27-99	31-80	46-116	40-106	38-10
Sample size	331	644	478	1,257	1,850	710	1,273	1,842	656	1,317	2,027	682	1,176	1,664	52
Micropogonias undulatus															
Mean length	35.7	25.2	34.9	38.0	40.2	28.6	49.5	51.3	45.2	82.4	66.7	72.1	99.8	101.6	81.
Range	22-38	9-56	21-57	25-78	10-78	16-72	21-96	26-104	18-95	26-126	28-133	30-168	55-148	61-163	50-14
Sample size	3	95	35	344	297	262	715	473	344	1,068	739	393	889	610	22
Cynoscion regalis															
Mean length	-	-	-	-	-	-	-	-	-	50.4	47.8	74	71.1	75.5	-
Range	-	-	-	-	-	-	-	-	-	14-99	18-81	-	30-120	31-129	-
Sample size	-	-	-	-	-	-	-	-	-	216	79	1	642	465	-
*Brevoortia tyrannus**															
Mean length	34.3	35.0	31.5	34.8	36.6	38.0	37.5	45.3	39.8	53.4	51.4	54.0	62.3	69.0	61.
Range	28-39	30-39	25-38	18-53	21-66	23-97	26-81	21-86	25-62	34-87	31-91	37-89	42-98	43-96	42-9
Sample size	193	33	96	574	309	419	537	394	289	216	342	44	254	145	2

Table 5 (continued)

Species	March N	March C	March S	April N	April C	April S	May N	May C	May S	June N	June C	June S	July N	July C	July S
*Anchoa mitchilli**															
Mean length	46.8	42.6	41.8	43.0	46.0	51.5	45.2	50.4	49.3	44.0	51.2	49.8	46.7	42.2	40.0
Range	22-89	20-76	21-71	22-82	23-86	29-93	20-82	19-96	28-83	16-86	20-96	19-86	16-92	17-106	20-84
Sample size	414	838	234	803	740	511	583	709	476	879	1,432	401	1,174	1,438	308
Bairdiella chrysoura															
Mean length	-	-	-	-	-	-	-	-	-	29.0	23.6	-	46.0	53.3	68.0
Range	-	-	-	-	-	-	-	-	-	12-67	11-42	-	16-103	19-82	51-88
Sample size	-	-	-	-	-	-	-	-	-	727	370	-	790	580	24
Paralichthys lethostigma															
Mean length	19.2	20.4	26.8	31.3	38.1	38.9	63.5	54.7	51.7	77.8	81.4	63.8	87.9	89.6	-
Range	12-25	15-28	10-38	37-54	21-57	26-70	27-122	29-81	38-81	42-120	42-149	54-92	62-124	43-137	-
Sample size	13	12	86	80	126	144	99	84	15	77	96	6	75	90	

*Species were measured in fork length (mm), others in total length (mm).

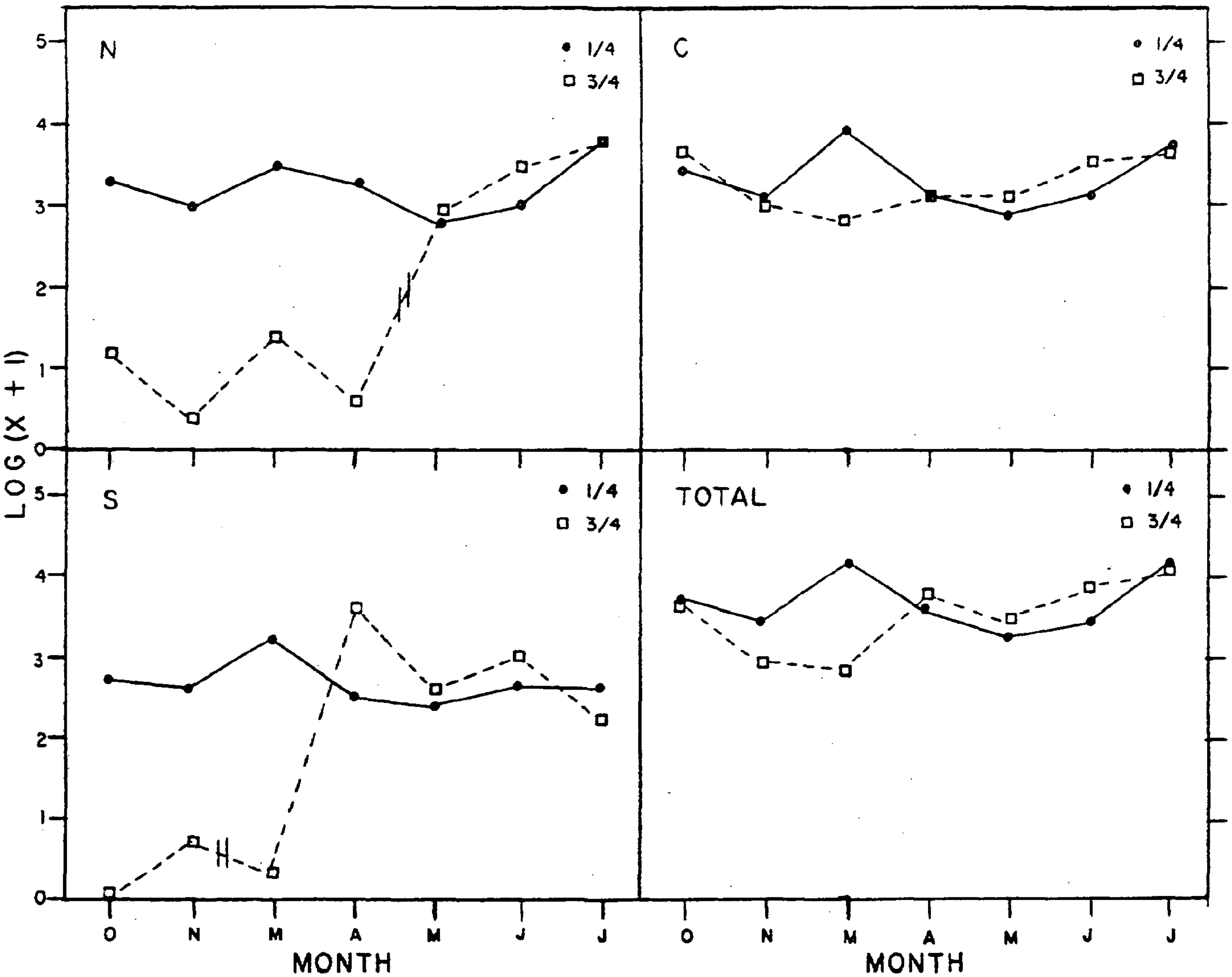

Figure 8. Seasonal abundance of *Anchoa mitchilli* in primary (1/4") and secondary (3/4") trawl stations in North Carolina during October and November, 1980 and March - July 1981. N=northern area, C=central area, S=southern area. Addition of 1/4" mesh tail bag to the 3/4" trawl is denoted by "//".

Bay anchovy recruitment appeared continuous, with individuals 15-20 mm FL found from March through July in the upper tributaries (Figure 9). Two apparent peaks of abundance in the primary stations were observed and were probably associated with juvenile recruitment. One peak was noted during March in the primary stations of all three regions. These fish were predominantly 25-50 mm FL, and apparently were the result of recruitment during fall or winter. The other abundance peak (July) for the northern and central regions was the reault of large numbers of new recruits (15-30 mm FL) first captured during June and reaching peak numbers a month later. Previous investigators have also noticed continuous bay anchovy recruitment in North Carolina waters. Williams and Deubler (1968a) found the greatest numbers of small anchovies in the Neuse River during June through August, with individuals less than 25 mm TL caught year around. Hobbie (1971) observed large numbers of bay anchovy larvae during June through August in the Cape Fear River. Mean lengths calculated from length frequency modes, also indicated continuous recruitment, as lengths increased and decreased randomly from month to month within areas (Table 5). Weinstein (1979) also reported monthly decreasing bay anchovy lengths in the Cape Fear River that were probably the result of bay anchovy recruitment.

Length frequencies were essentially unimodal in the upper tributaries until June, when large numbers of newly recruited bay anchovies were captured. Most of the recruits were found in the shallow marsh and creak habitat; however, gear selectivity may have accounted for low recruit numbers in deeper waters. The secondary areas were inhabited by large quantities of bay anchovies during summer, ranging from 45 to 75 mm FL (Figure 10). Those fish possibly had migrated from primary areas as indicated by length frequencies and abundance data. Migration into open waters was observed during April and May for the southern region, as shown by large increases in anchovy abundance in the secondary areas, accompanied by decreased catches in primary areas. Abundance in the secondary areas of the northern and central regions increased gradually from spring through summer, and primary station catches decreased from March through May. Bay anchovies were still abundant in estuarine waters during October and November.

Bairdiella chrysoura (Lacepede)-Silver perch

Silver perch is a common sciaenid, ranging from New York to Texas (Hildebrand and Schroeder 1928). The species is commonly found throughout the year in estuarine

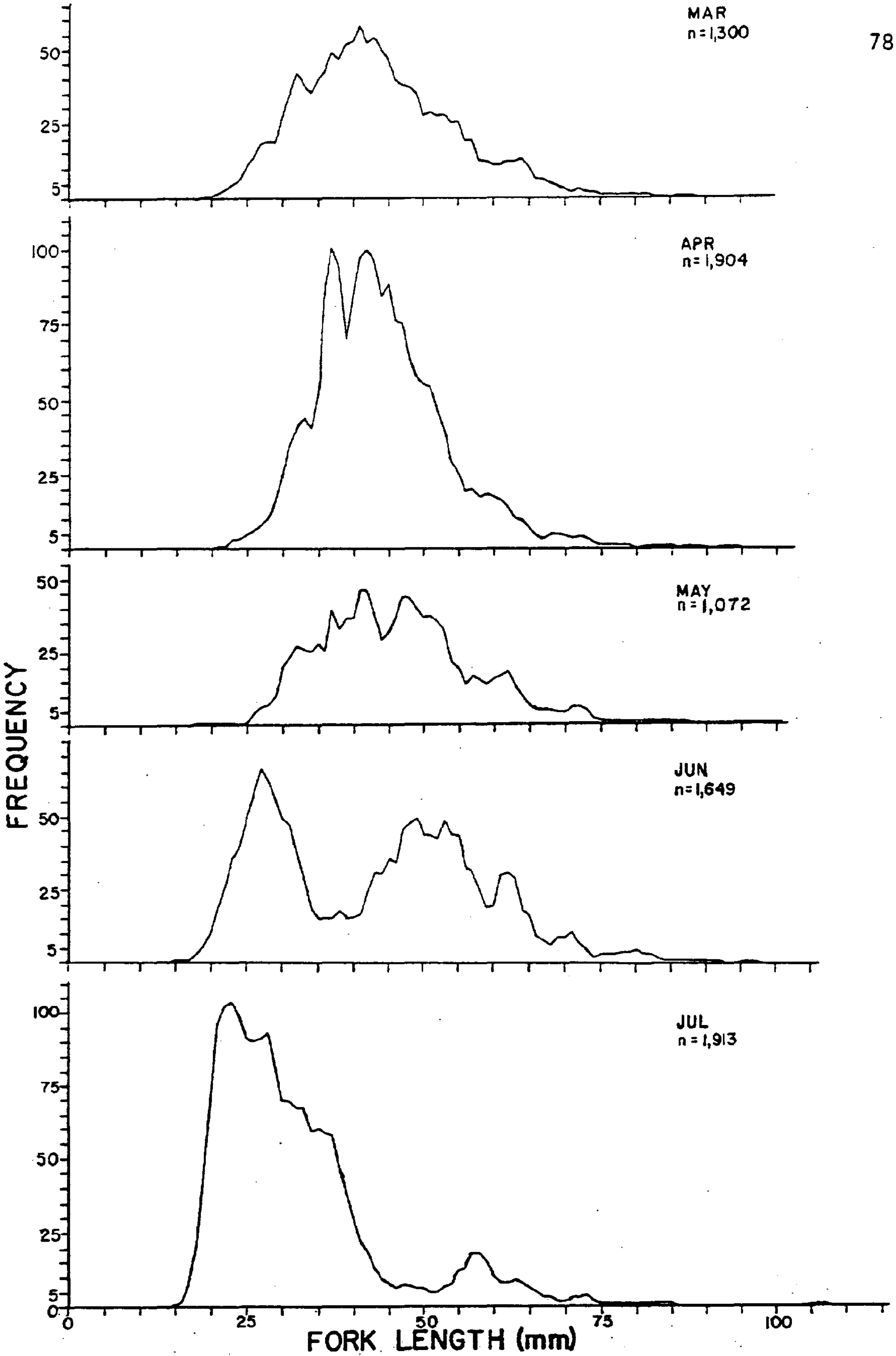

Figure 9. Length frequencies of *Anchoa mitchilli* captured in primary stations in North Carolina (March-July, 1981).

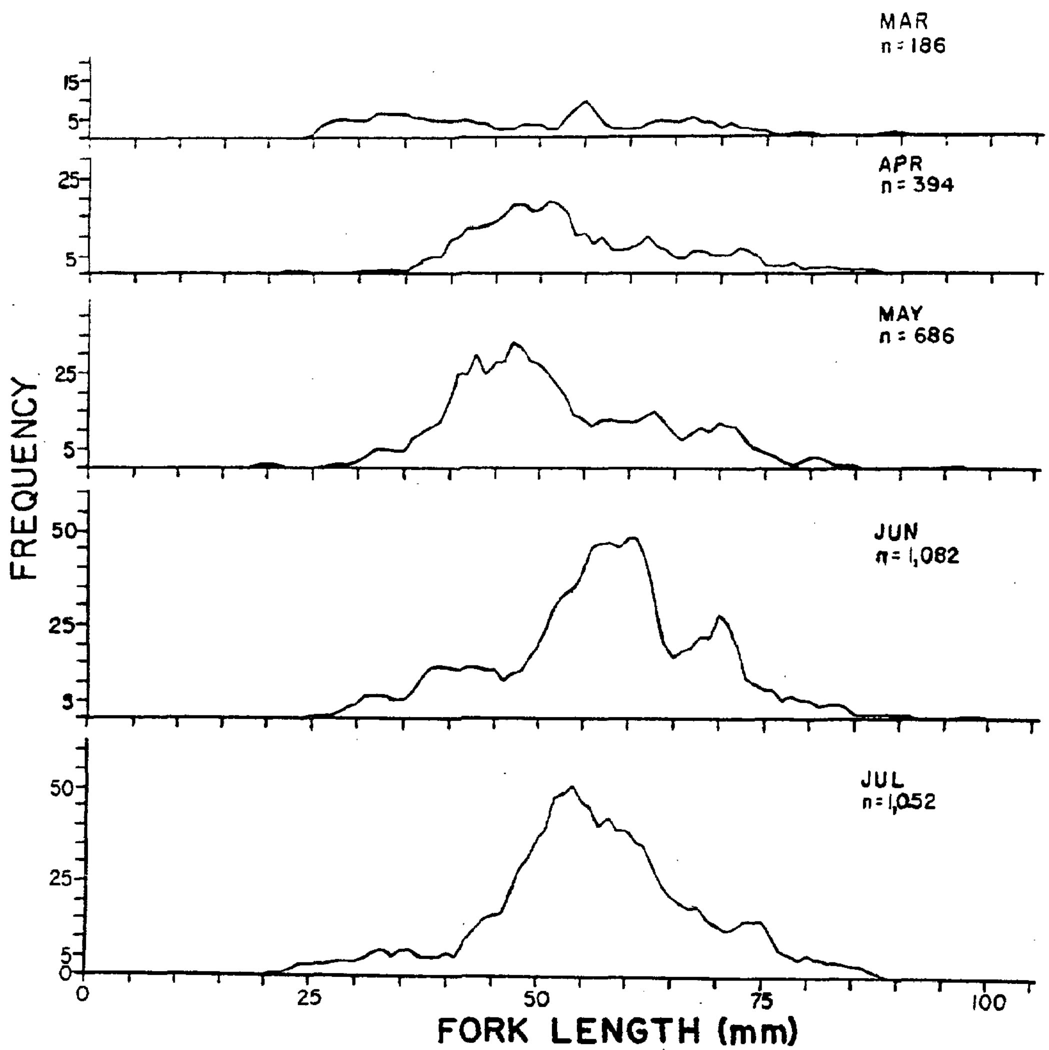

Figure 10. Length frequencies of *Anchoa mitchilli* captured in secondary stations in North Carolina (March-July, 1981).

waters of the south Atlantic and Gulf of Mexico, but is usually most abundant during late summer or early fall (Gunter 1938, Dahlberg and Odum 1970, Chao and Musick 1977). Spawning of silver perch is considered to take place in estuarine or nearshore oceanic waters. Numerous investigators have noted that silver perch spawn from spring to summer throughout their range. Dahlberg (1972) found that spawning in Georgia occurred during April and May. Hildebrand and Cable (1930) found eggs from April to June in North Carolina while Chao and Musick (1977) thought spawning ranged from late spring to early summer in Chesapeake Bay. After hatching, young juveniles migrate to various estuarine habitats, where they grow rapidly (Hildebrand and Cable 1930). Most juveniles begin migration during fall into more open waters and by winter, the majority have moved offshore (Gunter 1945, Christmas and Waller 1973, Chao and Musick 1977). Due to their small size, silver perch are not commercially important in North Carolina, but commonly occur in the bycatch of other fisheries.

A total of 11,097 silver perch were captured during the study period, representing 3% of the total finfish catch and ranking fourth in total abundance. Catches of silver perch fluctuated greatly within each region. Individuals were present in estuarine waters throughout the sampling period, except in the northern area, where none were caught during November, March, and May (Figure 11). A noticeable increase in abundance occurred during June and July in the northern and central areas, attributable to recruitment of young-of-the-year into estuarine waters. Spitsbergen and Wolff (1974) and Purvis (1976) observed high numbers of small silver perch in Pamlico Sound slightly later (July-August). Very low catches of juvenile silver perch were observed in the southern area relative to the other two state regions, especially during June and July. Individuals thought to be young-of-the-year ranged in size from 8 to 50 mm TL in the primary stations, with a mode of about 25 mm TL (Figure 12). In the secondary stations young-of-the-year ranged from 8 to 67 mm TL, with the majority about 30 mm TL during June. The large size range for newly recruited young-of-the-year was also observed by Shealy et al. (1974) and Chao and Musick (1977). Although recruitment primarily occurred in June, a few individuals less than 20 mm TL were noted during July. Recruitment periods as indicated by length frequencies agreed with the reported spawning period of late April to late June (Hildebrand and Cable 1930).

The easily discernible length frequency modes and mean lengths calculated from those modes indicated that young-of-the-year growth was rapid (Table 5).

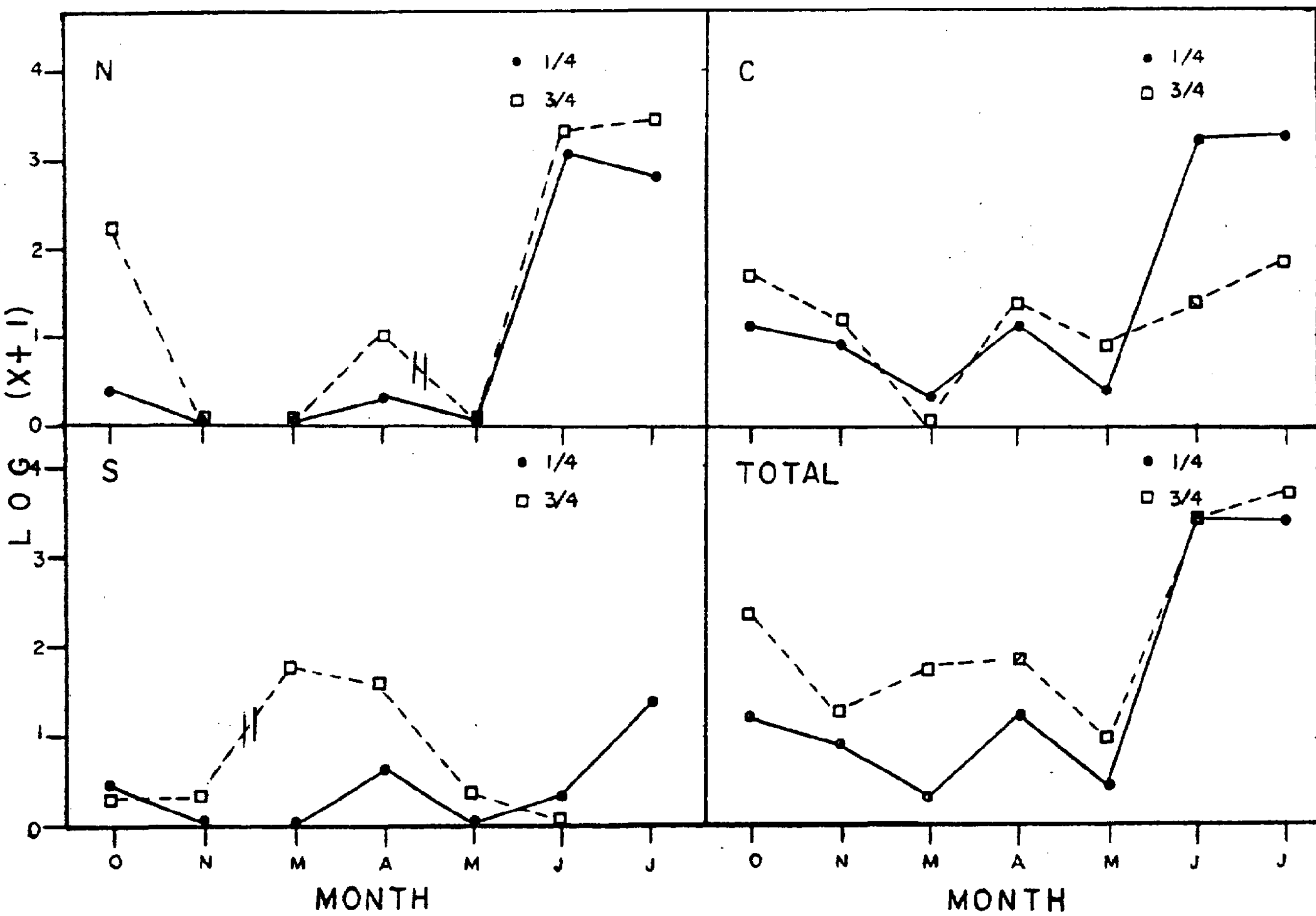

Figure 11. Seasonal abundance of *Bairdiella chrysoura* in primary (1/4") and secondary (3/4") trawl stations in North Carolina during October and November, 1980 and March-July 1981. N=northern area, C=central area, S=southern area. Addition of 1/4" mesh tail bag to the 3/4" trawl is denoted by "//".

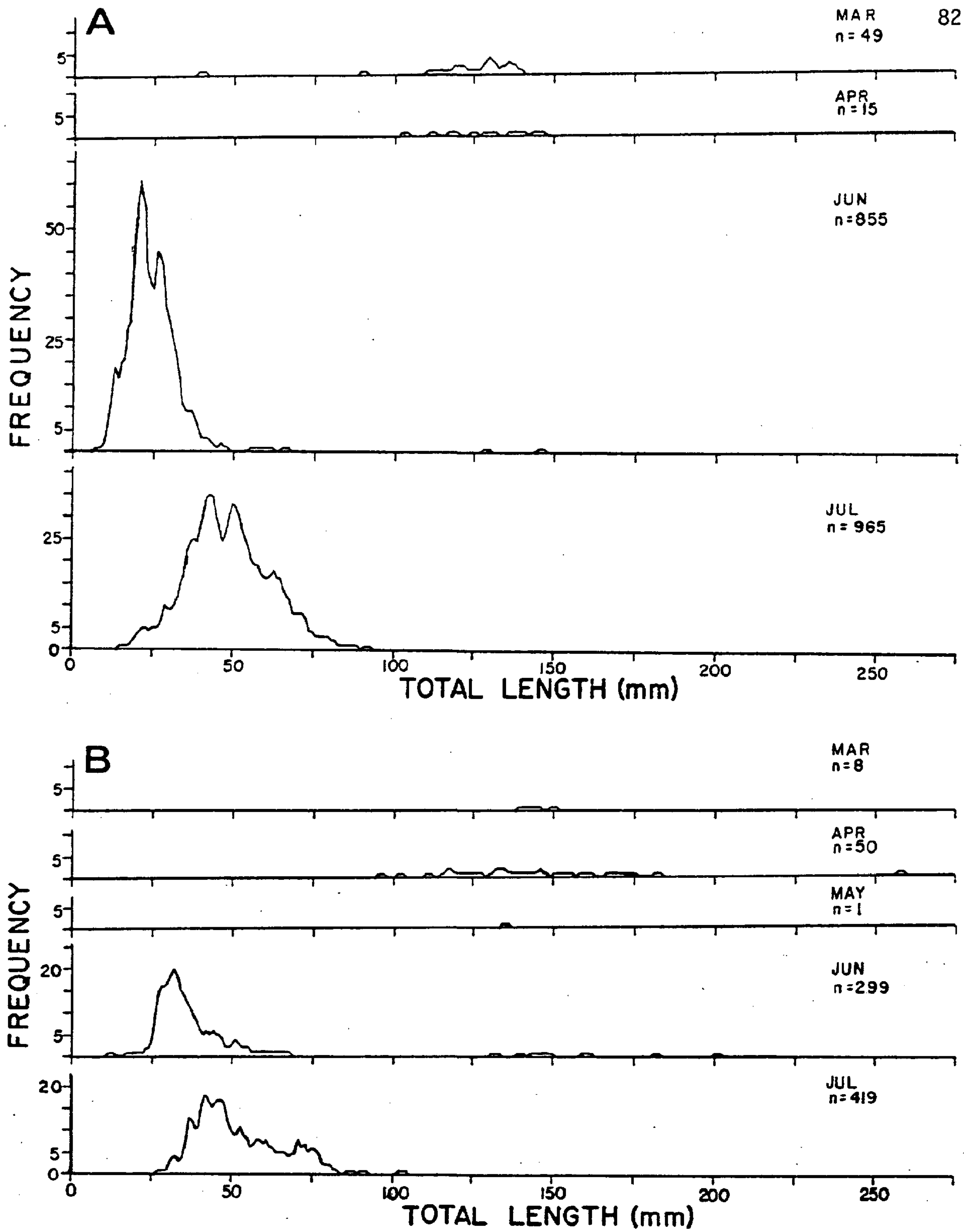

Figure 12. Length frequencies of *Bairdiella chrysoura* captured in primary (A) and secondary (B) stations in North Carolina (March-July, 1981).

Length estimates corresponded with observations of Hildebrand and Cable (1930) and Christmas and Waller (1973), who noted an average monthly growth of 15 mm TL during the warmer months in North Carolina and Mississippi, respectively. Hildebrand and Cable (1930) found that silver perch averaged 120 mm TL by the end of their first year. Length frequency plots also showed that at least two year classes of silver perch utilized estuarine waters. The majority of the larger fish (greater than 90 mm TL) captured during March through May appeared to be the result of the previous spring/summer spawn. Other investigators have noted similar sizes of perch in estuaries during spring (Dahlberg 1972, Shealy et al. 1974, and Chao and Musick 1977). Some yearlings were still present in the estuaries when recruitment of the new year class first occurred, but by July had migrated out of the creeks and bays.

Very few silver perch were found in estuarine waters during the fall, except in the open waters of the northern and central areas, where a large number of individuals 95-175 mm TL were captured. Abundance data indicated that most of the perch had migrated out of the estuarine tributaries by November. Abundance data also exhibited an apparent difference in habitat preference by silver perch juveniles between the northern and central areas during recruitment. Recruits in northern Pamlico Sound were abundant in both shallow tributaries and open waters, while those in western Pamlico Sound were noticeably more common in shallow tributaries than in open waters.

Cynoscion regalis (Bloch and Schneider)-Weakfish

The weakfish or gray trout is a littoral sciaenid, commonly found from Massachusetts to Florida (Hildebrand and Cable 1934). Weakfish is a major commercial and recreational species from North Carolina to New York (Bigelow and Schroeder 1953). Historically, most of the commercial catch came from off the coasts of New York and New Jersey, but since 1958, North Carolina has been the major weakfish-producing state along the Atlantic coast. North Carolina weakfish landings have risen rapidly since 1975, reaching 9.196 mt in 1980 (K.B. West,pers. comm). Although weakfish are presently relatively abundant, the stocks have apparently fluctuated widely in abundance (Joseph 1972).

More information has been published about the reproductive biology of weakfish than any other sciaenid studied along the Atlantic coast of the United States.

Several researchers have reported weakfish spawning around the inlets and in nearshore areas along the coast of North Carolina (Welsh and Breder 1923, Higgins and Pearson 1928, Hildebrand and Cable 1934). Merriner (1976) noted that weakfish may also spawn in North Carolins's sounds and bays. Weakfish spawning has been documented along the Atlantic coast from the Gulf of Maine to Georgia (Pearson 1941, Harmic 1958, Dahlberg 1972). The magnitude of northern area spawning is unknown (Merriner 1976). Harmic (1958) concluded that spawning activity north of Chesapeake Bay was insufficient to maintain the northern stock. Questions remain as to whether Chesapeake Bay and nearshore waters serve as major weakfish spawning grounds (Chao and Musick 1977). Massman (1963) suggested the southern spawning stocks may provide Chesapeake Bay's weakfish population.

Merriner (1976) reported weakfish spawning in North Carolina from March through August and reported peak spawning activity from April through June. He also observed a second spawn of smaller magnitude in late July and August. After hatching, weakfish larvae are dispersed by either wind or lunar tides into the estuaries (Hildebrand and Cable 1934, Massman et al. 1958). The sounds and bays of North and South Carolina, Virginia, and Maryland serve as nursery grounds for young juveniles along the Atlantic coast (Merriner 1973). Growth is rapid once the weakfish enter the estuaries (Pearson 1941, Massman et al. 1938, Merriner 1973). The juveniles remain in the estuaries until late fall or realy winter, when they migrate to deeper, more open waters (Hildebrand and Cable 1934, Massman et al. 1958, Merriner 1973).

Weakfish are exploited by many fisheries in North Carolina. Long haul seines and pound nets are two major gears used to harvest weakfish in Pamlico Sound and its tributaries. Wolff (1972) stated that substantial numbers of small weakfish were taken incidentally with shrimp trawls, long haul seines, and pound nets. In recent years, a large offshore winter trawl fishery for weakfish has developed along the North Carolina coast.

A total of 7,365 weakfish were captured during the investigation, representing 2% of the total finfish catch. Weakfish were captured throughout the study period, except during November, March, and April in the northern area, March in the central area, and November and March in the southern area (Figure 13). They were not abundant anywhere until June and July, when large numbers of newly recruited young-of-the-year were captured. Juveniles were captured only in the

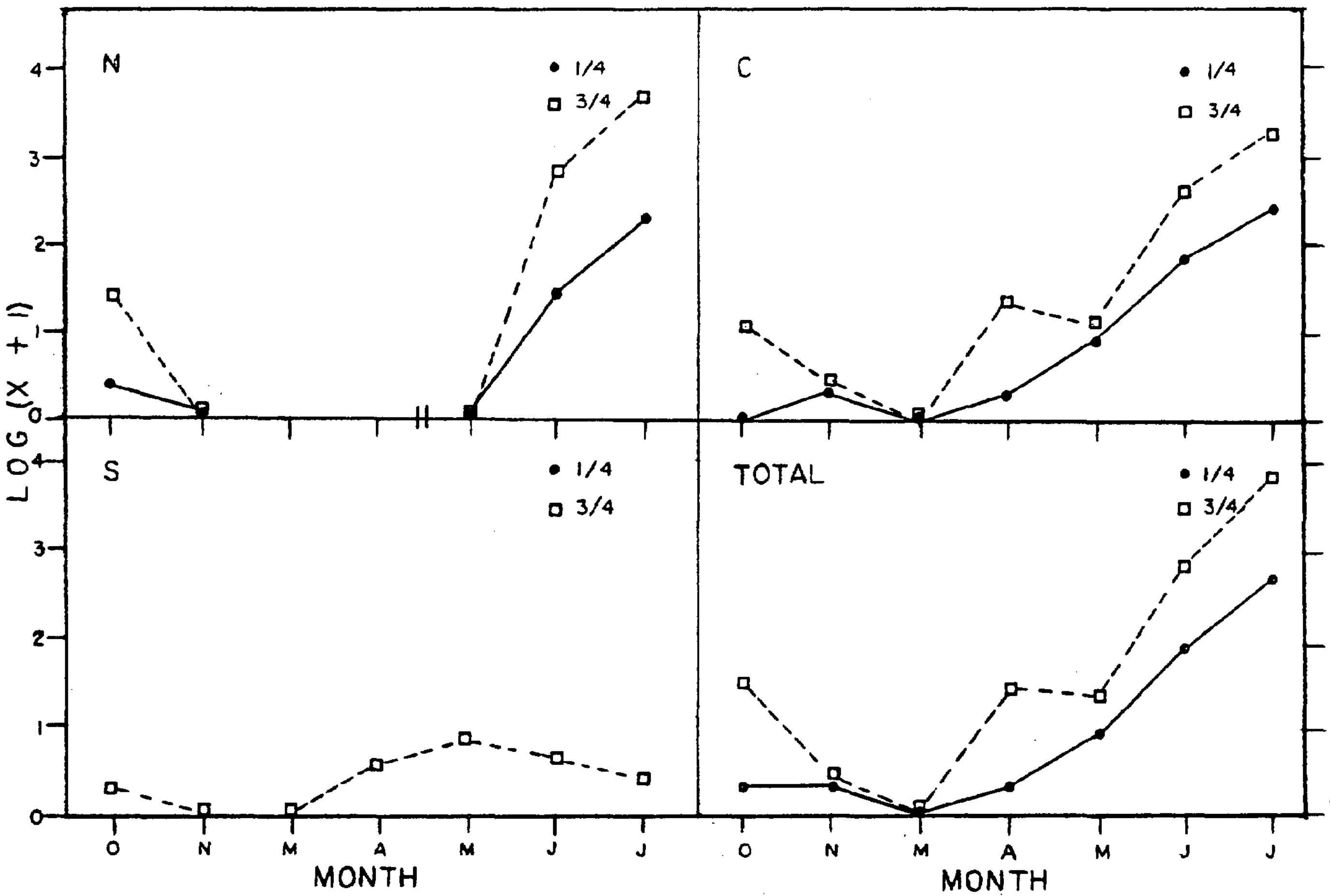

Figure 13. Seasonal abundance of *Cynoscion regalis* in primary (1/4") and secondary (3/4") trawl stations in North Carolina during October and November, 1980 and March-July 1981. N=northern area, C=central area, S=southern area. Addition of 1/4" mesh tail bag to the 3/4" trawl is denoted by "//".

northern and central regions, with tributaries of Pamlico Sound serving as the major nursery areas. Juvenile weakfish were first noted during June at a size range of 19-99 mm TL (Figures 14 and 15). Recruitment times in Pamlico Sound indicated that spawning occurred earlier than previously reported by Spitsbergen and Wolff (1974) and Purvis (1976). Recruitment times substantiated Merriner's (1976) conclusion that the weakfish spawning peak occurred from late April/early May through June in North Carolina. Peak weakfish numbers were observed during July, when large quantities of young-of-the-year were present in the estuaries, agreeing with the findings of former Pamlico Sound investigations (Purvis 1976; Ross 1980, in press). Hobbie (1971) noted peak abundance of young weakfish in the Cape Fear River during July and commented that weakfish was the most abundant finfish in the estuary from summer through fall. In contrast, Ross (1980, in press) and the present investigation found very low numbers of weakfish in the southern region. No weakfish were captured in the primary stations of the southern region.

Length frequencies and mean lengths calculated from length frequency modes (Table 5) indicated rapid growth for juveniles, agreeing with the results of previous investigations (Hildebrand and Cable 1932, Massman et al. 1958, Chao and Musick 1977). Length frequencies showed at least two size classes present in estuarine tributaries. The few weakfish captured in the fall of 1980 (57-210 mm TL) appeared to be young-of-the-year and yearlings. During the spring, relatively large individuals (89-188 mm TL) were still evident in the tributaries. The majority were probably approaching a year in age. Extended and multiple spawning made separation of year classes by size difficult, except during major recruitment periods. Two size modes were obvious in June and July. Fish greater than 120 mm TL were probably yearlings, while those less than 120 mm TL were probably a mixture of slower growing/later recruited individuals of the 1980 year class and newly recruited young-of-the year. Merriner (1973) found most weakfish reached 200 mm TL their first year.

Weakfish were consistently more abundant in catches from the secondary stations (Figure 13). New recruits seemed to favor the secondary areas as nursery habitat, reaffirming similar observations by Spitsbergen and Wolff (1974), Purvis (1976), and Baisden (1979). Most weakfish migrated out of the tributaries by late fall and did not return until April. Age 0 weakfish were more abundant in 1981 in the northern and central areas' primary stations than during 1979 and 1980 (Table 6). Catch-per-unit-effort data exhibited larger weakfish catches with the 3/4" trawl when the tail bag mesh size was decreased in 1981.

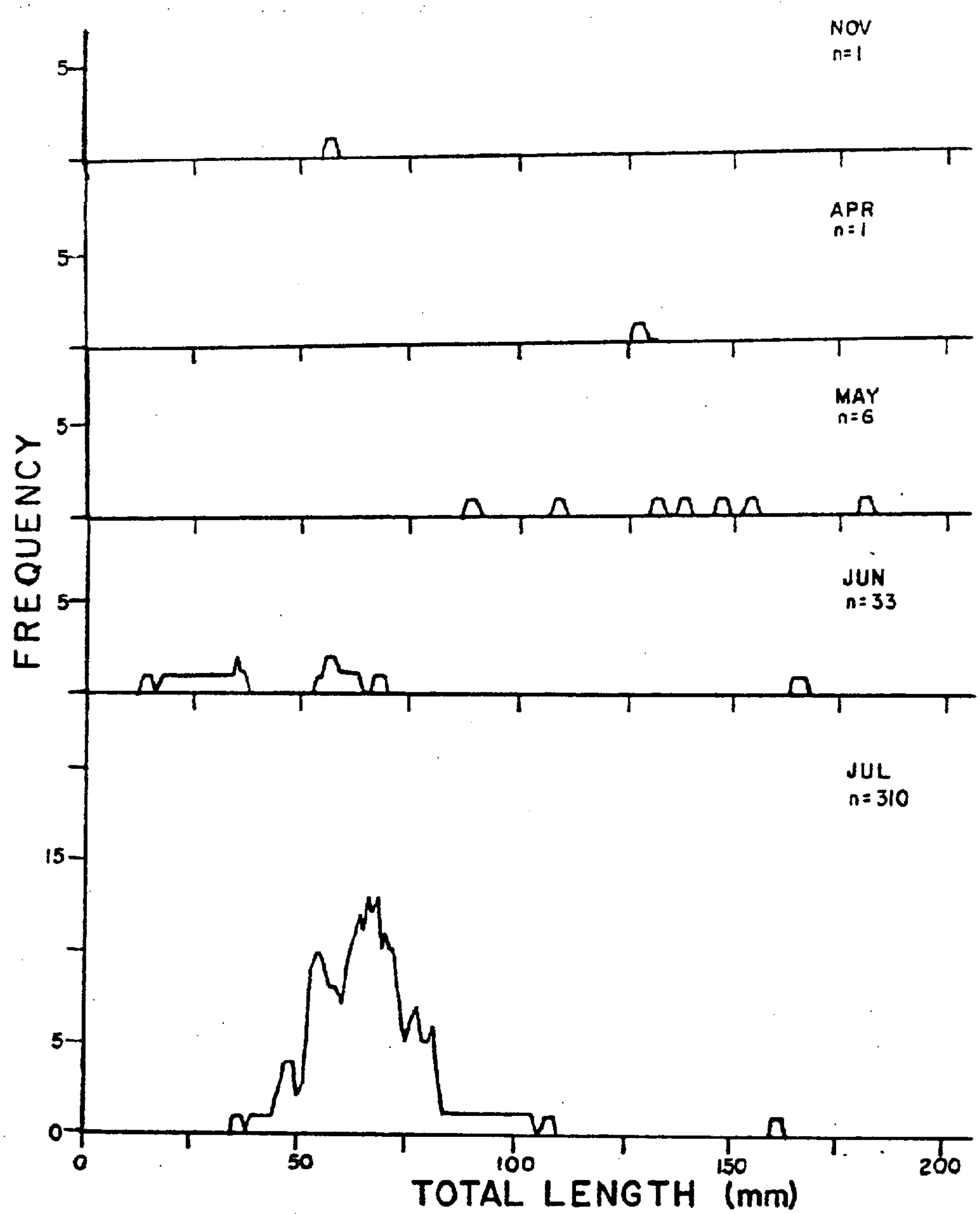

Figure 14. Length frequencies of *Cynoscion regalis* captured in primary stations in North Carolina (October and November, 1980 and March-July, 1981).

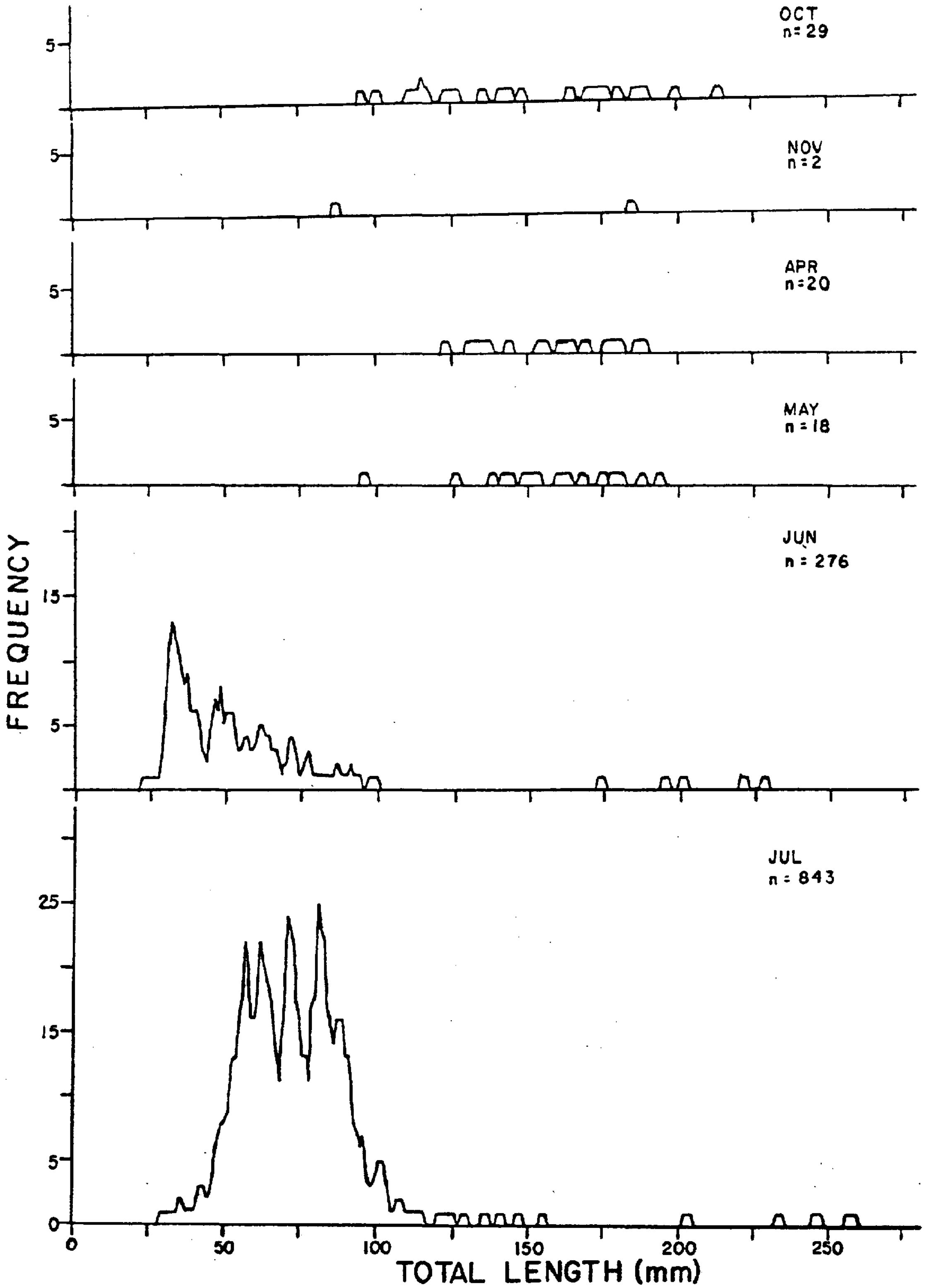

Figure 15. Length frequencies of *Cynoscion regalis* captured in secondary stations in North Carolina (October and November 1980 and March-July, 1981).

Table 6. Catch per unit effort data (No. fish/trawl) by general area in North Carolina estuarine waters for major commercial species, March - July, 1979-81.[1]

		Northern Area									
		March		April		May		June		July	
Species	Year	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl
Leiostomus xanthurus	1979	93.73	1.33	331.74	34.20	254.16	12.27	186.32	2.71	62.70	18.00
	1980	16.32	2.31	96.00	19.63	92.73	15.56	66.55	16.88	28.39	13.94
	1981	101.38	3.62	450.59	31.33	496.16	715.93[2]	143.39	13.07[2]	55.37	311.69[2]
Micropogonias undulatus	1979	13.06	0.00	76.87	2.20	89.25	23.87	54.00	26.64	23.09	22.40
	1980	1.39	0.19	30.34	1.88	67.36	4.38	69.15	24.44	32.15	12.56
	1981	0.15	0.00	22.28	1.53	32.19	47.20[2]	29.12	76.73[2]	19.13	90.94[2]
Cynoscion regalis	1979	0.00	0.00	0.00	0.13	0.00	0.33	0.19	1.21	0.58	0.40
	1980	0.00	0.00	0.00	0.06	0.00	0.06	0.15	0.06	1.24	2.00
	1981	0.00	0.00	0.00	0.00	0.00	0.00	0.76	34.40[2]	5.73	265.94[2]
Paralichthys lethostigma	1979	0.03	0.07	1.81	0.00	1.50	1.13	1.29	0.86	0.70	0.47
	1980	0.71	0.38	1.06	0.44	2.48	0.25	2.24	0.69	1.58	1.13
	1981	0.54	0.00	2.56	0.13	2.42	1.60[2]	2.00	1.20[2]	2.10	1.38[2]
No. trawls (units of effort)	1979	33	15	31	15	32	15	31	14	33	15
	1980	31	16	32	16	33	16	33	16	33	16
	1981	34	16	26	15	26	13	32	15	31	15

Table 6. (continued).

		Central Area									
		March		April		May		June		July	
Species	Year	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl
Leiostomus xanthurus	1979	41.14	37.56	357.32	16.89	247.49	1.50	159.21	2.67	73.14	5.22
	1980	1.02	54.61	124.11	15.50	115.60	18.44	53.20	20.39	36.11	14.39
	1981	63.51	5.00[2]	483.72	705.50[2]	218.34	1132.56[2]	178.00	673.28[2]	65.67	333.94[2]
Micropogonias undulatus	1979	4.65	4.44	63.52	3.33	50.09	5.31	32.00	15.17	17.36	12.67
	1980	2.21	223.89	20.37	10.72	75.16	23.72	62.39	23.94	30.78	23.12
	1981	2.21	0.94[2]	9.14	33.89[2]	6.79	31.94[2]	9.63	60.67[2]	4.37	52.94[2]
Cynoscion regalis	1979	0.00	0.50	0.18	0.61	0.30	0.75	0.07	2.00	1.61	2.06
	1980	0.00	0.00	0.00	0.17	0.03	2.72	0.44	0.17	0.20	0.84
	1981	0.00	0.00[2]	0.02	0.49[2]	0.18	0.88[2]	1.58	12.94[2]	6.44	101.17[2]
Paralichthys lethostigma	1979	1.12	0.17	2.59	0.00	2.63	0.25	1.40	0.28	0.70	0.00
	1980	0.22	0.78	1.33	1.23	2.73	0.17	1.44	0.62	1.04	0.67
	1981	0.44	0.83	3.12	0.56	2.08	1.60	2.49	1.20	1.40	1.38
No. trawls (units of effort)	1979	43	18	44	18	43	16	43	18	44	18
	1980	43	18	46	18	45	18	46	18	45	18
	1981	43	18	43	18	43	18	43	18	38	16

Table 6. (continued).

		Southern Area									
		March		April		May		June		July	
Species	Year	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl	1/4 trawl	3/4 trawl
Leiostomus xanthurus	1979	164.33	14.16	1004.22	3.67	186.06	2.50	74.33	2.67	45.78	2.42
	1980	112.94	78.67	405.39	59.42	257.00	13.33	87.17	2.08	46.72	2.50
	1981	558.28	257.75[2]	1367.92	566.17[2]	138.50	1453.94[2]	112.17	46.25[2]	40.67	20.58[2]
Micropogonias undulatus	1979	2.67	0.50	12.44	1.67	16.28	1.42	23.56	9.08	9.22	2.50
	1980	4.00	14.75	10.44	100.92	46.27	20.33	26.78	14.42	14.11	3.33
	1981	2.28	54.17[2]	16.44	156.08[2]	17.61	137.17[2]	12.83	25.50[2]	13.67	26.08[2]
Cynoscion regalis	1979	0.00	0.08	0.00	0.00	0.00	0.17	0.00	0.50	0.00	0.33
	1980	0.00	0.17	0.00	1.33	0.00	0.50	0.00	0.17	0.00	0.08
	1981	0.00	0.00	0.00	0.33[2]	0.00	0.58[2]	0.00	0.33[2]	0.00	0.17[2]
Paralichthys lethostigma	1979	15.00	0.17	9.28	0.08	0.11	0.00	0.56	0.33	0.11	0.00
	1980	1.22	0.33	5.00	0.67	2.33	0.08	0.56	0.17	0.00	0.00
	1981	4.89	0.00	11.78	0.67[2]	0.78	0.67[2]	0.28	0.17[2]	0.00	0.17[2]
No. trawls (units of effort)	1979	18	12	18	12	18	12	18	12	18	12
	1980	18	12	18	12	18	12	18	12	18	12
	1981	18	12	18	12	18	12	18	12	18	12

Table 6. (continued).

All Areas Combined

Species	Year	March 1/4 trawl	March 3/4 trawl	April 1/4 trawl	April 3/4 trawl	May 1/4 trawl	May 3/4 trawl	June 1/4 trawl	June 3/4 trawl	July 1/4 trawl	July 3/4 trawl
Leiostomus xanthurus	1979	83.19	19.24	474.54	19.13	237.89	5.53	151.74	4.73	64.33	8.73
	1980	28.07	44.64	176.68	29.68	141.63	16.84	92.00	15.05	32.09	11.64
	1981	165.55	77.44[2]	657.12	442.96[2]	300.82	734.09[2]	153.24	419.33[2]	57.33	244.46[2]
Micropogonias undulatus	1979	7.22	1.91	58.09	2.51	57.02	10.70	37.76	17.16	17.81	13.20
	1980	2.28	95.68	23.03	32.59	70.75	16.84	61.24	22.61	45.98	14.93
	1981	1.61	15.51[2]	15.08	55.69[2]	18.08	66.63[2]	17.09	56.64[2]	11.08	59.15[2]
Cynoscion regalis	1979	0.00	0.22	0.09	0.29	0.14	0.44	0.10	1.34	0.95	1.04
	1980	0.00	0.05	0.00	0.45	0.01	1.27	0.27	0.14	0.55	1.09
	1981	0.00	0.00	0.01	0.55[2]	0.08	0.49[2]	0.99	16.73[2]	4.93	141.90[2]
Paralichthys lethostigma	1979	3.39	0.13	3.62	0.02	1.75	0.49	1.20	0.48	0.59	0.16
	1980	0.39	0.55	1.33	0.87	2.71	0.18	1.63	0.55	1.09	0.41
	1981	1.39	0.35[2]	4.60	0.44[2]	1.93	1.30[2]	1.89	0.84[2]	1.35	1.50[2]
No. trawls (units of effort)	1979	94	45	93	45	93	43	92	44	95	45
	1980	92	44	91	44	91	44	92	44	91	44
	1981	87	43	93	45	87	43	94	45	91	46

[1]Data for 1979 taken from Ross (1980); data for 1980 taken from Ross (*In press*).

[2]A 1/4 inch bar mesh tail bag was added to the 3/4 inch flat trawl in 1981 replacing the original 3/4 inch bar mesh tail bag used in 1979-80.

Leiostomus xanthurus (Lacépede) Spot

The spot is a commercially and recreationally important sciaenid species found along the Atlantic Coast and Gulf of Mexico from Massachusetts to the Bay of Campeche (Chao 1978). Historically, a large commercial fishery existed for spot in the south Atlantic and Chesapeake Bay (Pacheco 1962), but recently the major production area has shifted solely to the south Atlantic, with North Carolina the principal Atlantic coast state harvesting spot. Spot ranks third among North Carolina sciaenids in poundage and value, behind croaker and weakfish. Long haul seines and pound nets are the predominant gears that commercially harvest spot in North Carolina (Sholar 1979; DeVries 1981, 1982). These fisheries are principally located in Pamlico Sound and its tributaries. Spot are also landed in large numbers as bycatch in the Pamlico Sound shrimp trawl fishery (Wolff 1972). During winter, spot are captured by the trawl fishery operating off the North Carolina coast (Pearson 1932).

Spot are one of the most frequently-studied sciaenids from the Gulf of Mexico and Atlantic coast. Spot along the Atlantic coast spawn during fall through winter, with the northern individuals usually spawning later than those in warmer waters (Dawson 1958, Pacheo 1962, Dahlberg 1972). The majority of spot apparently spawn offshore (Hildebrand and Cable 1930, Dawson 1958, Pacheco 1962). Postlarvae enter the estuaries of the Gulf and Atlantic coasts from late fall through spring (Dawson 1958, Sundararaj 1960, Pacheco 1962). Spot usually remain in the estuaries until the following fall, when a general migration to open waters begins (Dawson 1958, Pacheco 1962, Chao and Musick 1977).

Spot was the most abundant finfish collected during the study. A total of 209,584 individuals were caught, representing almost 62% of the total juvenile fish captured. Spot were present throughout North Carolina's coastal estuaries during the entire study period, being most abundant during spring and least abundant during fall (Figure 16). Newly spawned juveniles first appeared in catches during March, at a size range of 15-41 mm FL (Figures 17 and 18). Small postlarvae (less than 15 mm TL) have been captured in North Carolina waters as early as December (Hildebrand and Cable 1930). Many North Carolina investigators have reported large numbers of new recruits during March and April (Tagatz and Dudley 1961, Williams and Deubler 1968a, Weinstein 1979). Small spot preferred the

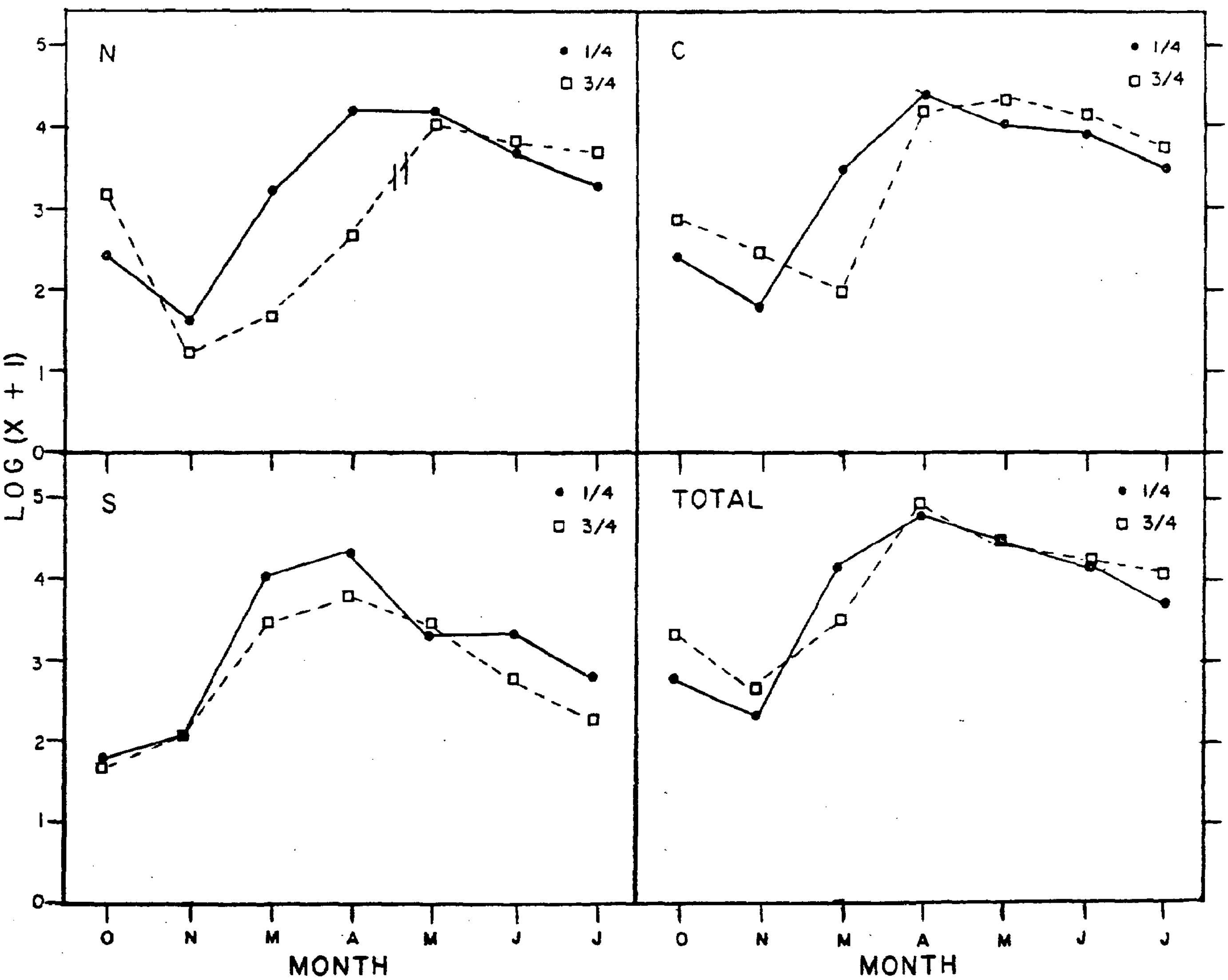

Figure 16. Seasonal abundance of *Leiostomus xanthurus* in primary (1/4") and secondary (3/4") trawl stations in North Carolina during October and November, 1980 and March-July, 1981. Addition of 1/4" mesh tail bag to the 3/4" trawl is denoted by "//".

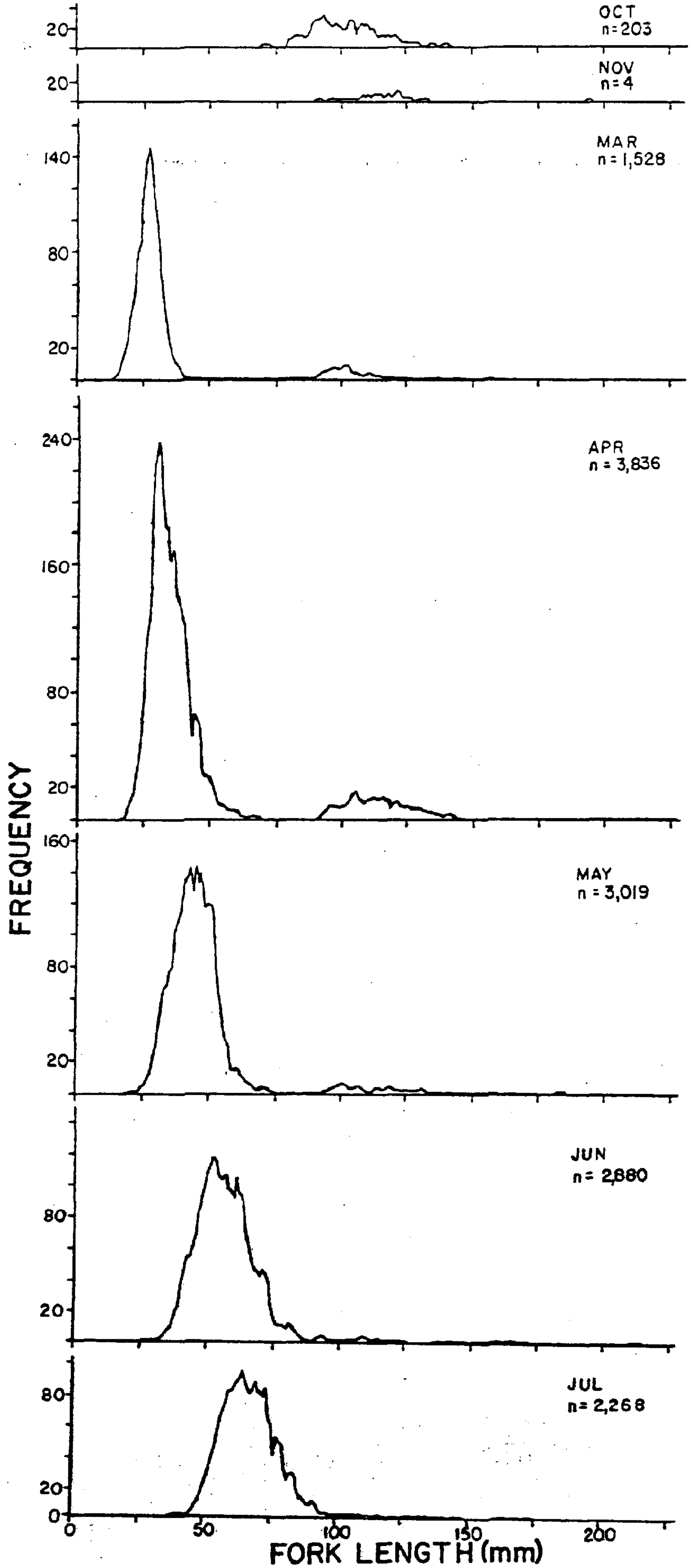

Figure 17. Length frequencies of *Leiostomus xanthurus* captured in primary stations in North Carolina (October and November, 1980 and March-July, 1981).

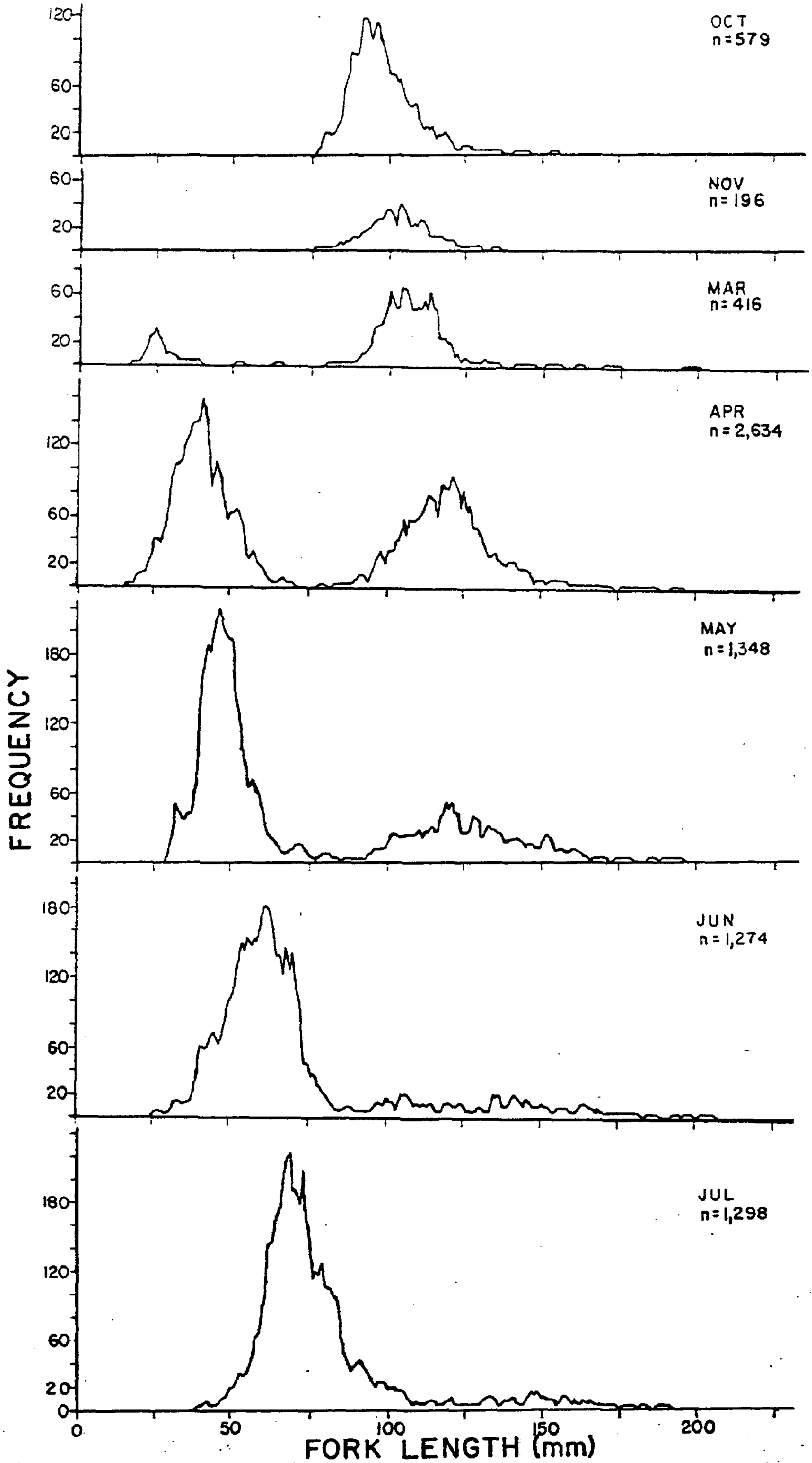

Figure 18. Length frequencies of *Leiostomus xanthurus* captured in secondary stations in North Carolina (October and November, 1980 and March-July, 1981).

shallow marshes and creeks as initial estuarine habitat, although large numbers were captured in the deeper waters of the southern area during March. Recruits were much more abundant during March in the southern region than in the other two regions (Figure 16). Peak numbers of recruits were noted in April in the primary stations at a size range of 15-70 mm FL. Many larger young-of-the-year spot (80-120 mm FL) were also observed in the secondary areas during April (Figure 18). Ross (1980, in press) also found high numbers of juvenile spot during April at comparable sizes.

Emigration from the shallow creeks and tributaries began during late April or May, as juvenile abundance in the primary stations of the central and southern areas declined significantly. Mass movement out of the primary stations in the northern area apparently did not begin until June (Figure 16). Length frequency data indicated the presence of slightly larger young-of-the-year spot in the more open waters as the season progressed. Spot numbers in both the primary and secondary stations of the southern area decreased more rapidly than those in the central and northern regions (Figure 16). Spot apparently migrated quickly out of the southern area's estuarine waters after peak recruitment in April, a phenomenon also noted by Weinstein (1979). Abundance and length frequency data showed that spot in the northern and central regions moved from primary areas to secondary areas after spring recruitment, and then gradually migrated into deeper waters.

At least two size classes of spot utilized North Carolina's eatuarine waters (Figures 17 and 18). According to age/length estimates, these size classes were composed of primarily young-of-the-year and yearlings (Dawson 1958, Sundararaj 1970, DeVries 1982). Length frequency modes were easily discernible during March through May in data from both the primary and secondary stations. Juveniles dominated catches in both the primary and secondary areas, except during March, when yearlings were abundant in the secondary stations. After May, young-of-the-year modes were still obvious; however, lengths from faster growing juveniles began to equal or exceed those of slower growing yearlings, making separation of year classes difficult. Monthly mean lengths calculated from juvenile length frequency modes are presented in Table 5.

The majority of spot captured during the fall were 75-125 mm FL. This range agreed with yearling sizes found elsewhere (Welsh and Breder 1923, Sundararaj 1960, Chao and Musick 1977). Similar-sized spot were also noted the following spring, indicating that some individuals overwintered in the estuaries or that some yearlings returned to the estuaries during spring. Yearling and older spot in Virginia estuaries leave those waters after September and do not return until the following spring (Chao and Musick 1977).

Catch rates for spot from the primary stations were consistently higher during 1981 than during the previous two years (Table 6). Most of these fish were juveniles. Significant increases in catches of spot in the secondary areas occurred when the stations were sampled with a 3/4" trawl having a smaller tail bag mesh.

Micropogonias undulatus (Linnaeus)-Atlantic croaker

The Atlantic croaker is one of the most important commercial and recreational species of the southeastern coastal states. It has been found from Nova Scotia to the Bay of Campeche (Chao 1978). Croakers account for more commercial poundage than any other sciaenid. In past years, the commercial fishery for croaker as foodfish was primarily located in the Chesapeake Bay area (Haven 1957), but recently the south Atlantic area has become the major producer of croaker for foodfish. Since 1976, North Carolina fishermen have harvested more croaker for foodfish than any other state. Croaker commercial landings in North Carolina increased from 1812 mt during 1973 to 9513 mt during 1980 (K. B. West, pers. comm.). Although North Carolina croaker landings are presently the highest ever recorded, croaker stocks have a history of dramatic fluctuations (Joseph 1972).

Atlantic croaker have an extended spawning period, ranging from late summer through early spring. Spawning north of Cape Hatteras commences during mid-August and is completed by January, with peak spawning occurring in October and November (Wallace 1940, Morse 1980). Haven (1957) and Chao and Musick (1977) inferred late winter or early spring spawning offshore Virginia based on length frequency data. White and Chittenden (1977) stated that croaker spawning in warm temperate waters extends from September to late March, with a peak during October. Atlantic croaker spawn for several months offshore North Carolina. Hildebrand and Cable (1930) captured individuals less than 10 mm TL during January through May and September through December near Beaufort Inlet. Hobbie (1971) and Weinstein et al. (1980) reported croaker larvae from October through April in the Cape Fear River.

Young croaker are transported into estuarine waters by currents (Wallace 1940, Haven 1957, Weinstein et al. 1980). Small croaker commonly prefer the deeper estuarine areas as nursery habitat (Haven 1957, Chao and Musick 1977, Weinstein 1979). However, large numbers of young croaker have also been observed in the marsh shallows of the Gulf of Mexico (Parker 1971, Arnoldi et al. 1974, Kobylinski and Sheridan 1979). Once in the nursery areas, growth is rapid. Most investigators have estimated young-of-the-year croaker reach 130-180 mm TL their first growing season (Welsh and Breder 1923, Haven 1957, White and Chittenden 1977). However, Louisiana researchers have estimated extremely high croaker growth rates, reaching a minimum of 200 mm their first year (Arnoldi et al. 1974, Knudsen and Herke 1978). Croaker begin leaving estuarine waters during late summer and early fall (Haven 1957, Shealy et al. 1974, Chao and Musick 1977). Tagging studies in the Gulf of Mexico have indicated that juvenile croaker sometimes migrate quickly out of tidal marshes, utilizing the nurseries for a maximum of four months (Arnoldi et al. 1974, Knudsen and Herke 1978).

A substantial commercial fishery exists for croaker within North Carolina's estuarine waters, primarily utilizing long haul seines and pound nets (Higgins and Pearson 1928; Sholar 1979; DeVries 1981, 1982). The winter trawl fishery and an expanding gill net fishery also exploit croaker off the North Carolina coast. Large numbers of small croaker are taken as bycatch in the Pamlico Sound shrimp trawl fishery (Fahy 1965, Wolff 1972).

A total of 17,244 Atlantic croaker were captured during the survey, representing 5% of the total juvenile fish catch. Croaker were relatively common, ranking third in abundance and being observed every month of the study period. Recruitment of recently spawned croaker (less than 20 mm TL) was observed in both fall and spring. Recruitment times generally agree with those found by previous North Carolina investigators (Hobbie 1971; Ross 1980, in press; Weinstein et al. 1980). Spring recruitment in the central and southern areas was observed during March, but was not noticed until April in the northern area. Peak numbers of newly recruited croaker were evident during April through June for all three regions. Early growth was rapid, with the majority of individuals ranging from 25-50 mm TL during April and reaching 75-125 mm TL by July. Length frequencies were similar to those recorded during 1980 (Ross, in press), but slightly smaller than those observed during 1979 (Ross 1980). North Carolina croaker captured in estuarine tributaries ranged predominantly from 100 to 175 mm TL in the fall of 1980 (Figures 19 and 20). These individuals were probably juveniles approaching a year in age,

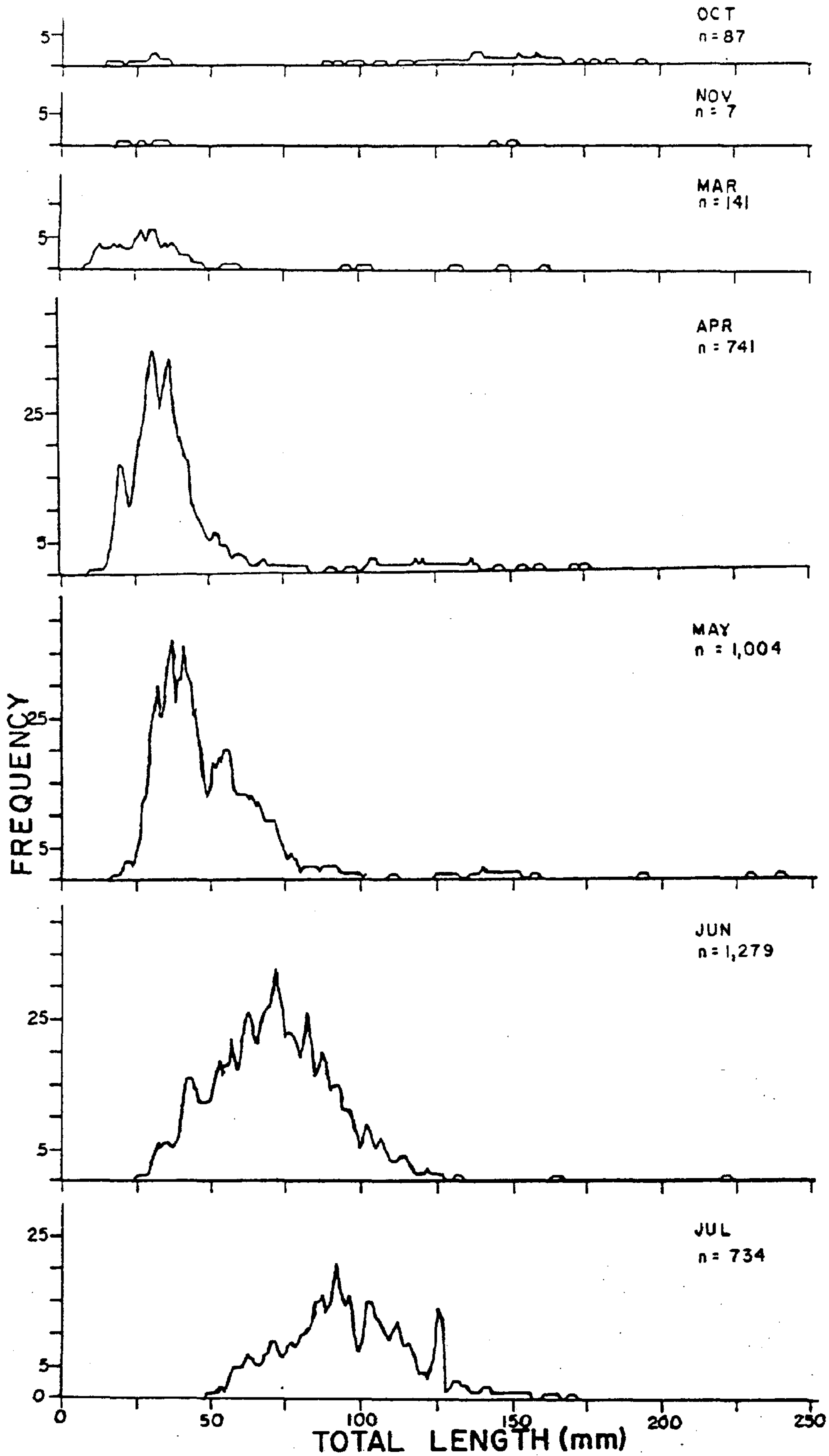

Figure 19. Length frequencies of *Micropogonias undulatus* captured in primary stations in North Carolina (October and November, 1980 and March-July, 1981).

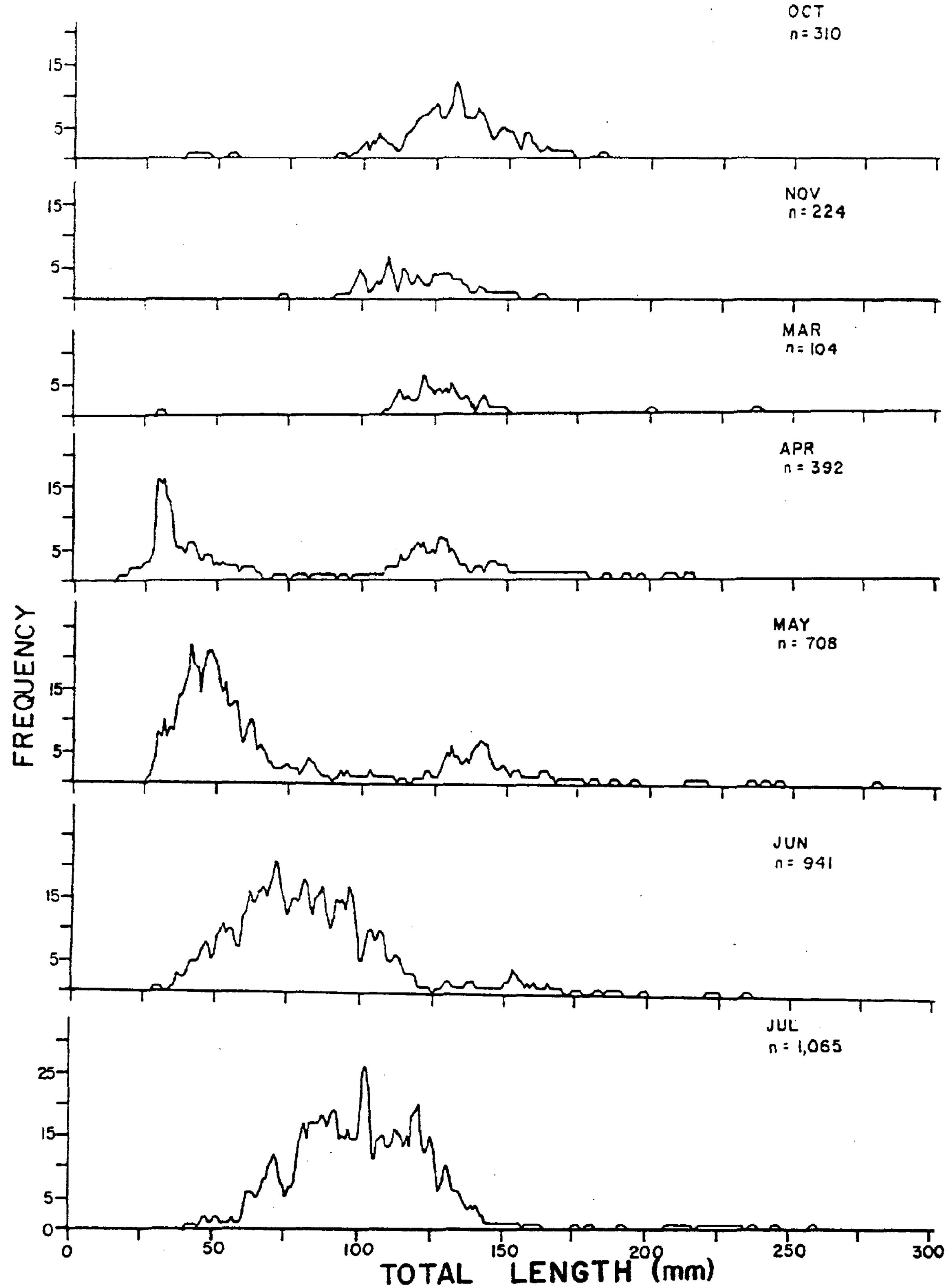

Figure 20. Length frequencies of *Micropogonias undulatus* captured in secondary stations in North Carolina (October and November, 1980 and March-July, 1981).

according to lengths observed or back-calculated from scale samples by other researchers (Bearden 1964, Chao and Musick 1977, White and Chittenden 1977). Ross 1982 (in press) estimated a mean back-calculated length at first annulus of 179 mm TL for North Carolina croaker. Monthly croaker mean lengths calculated from length frequency modes are shown on Table 5.

Several croaker size classes utilized the estuarine tributaries of North Carolina. During the fall of 1980, croakers less than 35 mm TL and those between 75-190 mm TL reflected two distinct size modes. The modes represented new juvenile recruits and fish probably approaching one year in age. New recruits were more common in the primary stations, while older individuals were more abundant in the deeper areas. Larger individuals (100-150 mm TL) captured in the spring had either overwintered in the estuaries or had migrated into the area from other estuarine waters. The yearling mode can be followed through May in the secondary areas. The yearling mode was accompanied throughout spring by a mode representing new recruits (Figures 19 and 20). Distinct separation of length frequency plots by year class was difficult due to rapidly growing young-of-the-year and slower growing yearlings. Young-of-the-year croaker were still present in both the primary and secondary areas during July.

Peak croaker numbers were observed during spring recruitment and lowest numbers during fall, corresponding with juvenile migration to open waters. (Figure 21). Croaker were more abundant in the secondary areas. Apparent differences in croaker relative abundances were noted between regions. Croaker inhabiting the southern area during the fall were more abundant in the primary areas, while croaker in the northern and central areas were more numerous in the deeper waters. Numbers rose during November in the southern area's primary stations, but declined noticeably in the other regions, especially in the northern area. Throughout spring, croaker from the southern region were much more abundant in deeper waters. The samples were composed of yearlings or older individuals (109-230 mm TL) during March and a mixture of young-of-the-year and yearlings during April and May (17-179 mm TL). Weinstein (1979) found that croaker in the Cape Fear River primarily utilized the main channel of the river as nursery habitat. Catches in the southern area's secondary stations dropped substantially during June and July, while abundance in the primary stations remained fairly steady through spring and summer (Figure 21). Croaker catches in the deeper waters of the northern and

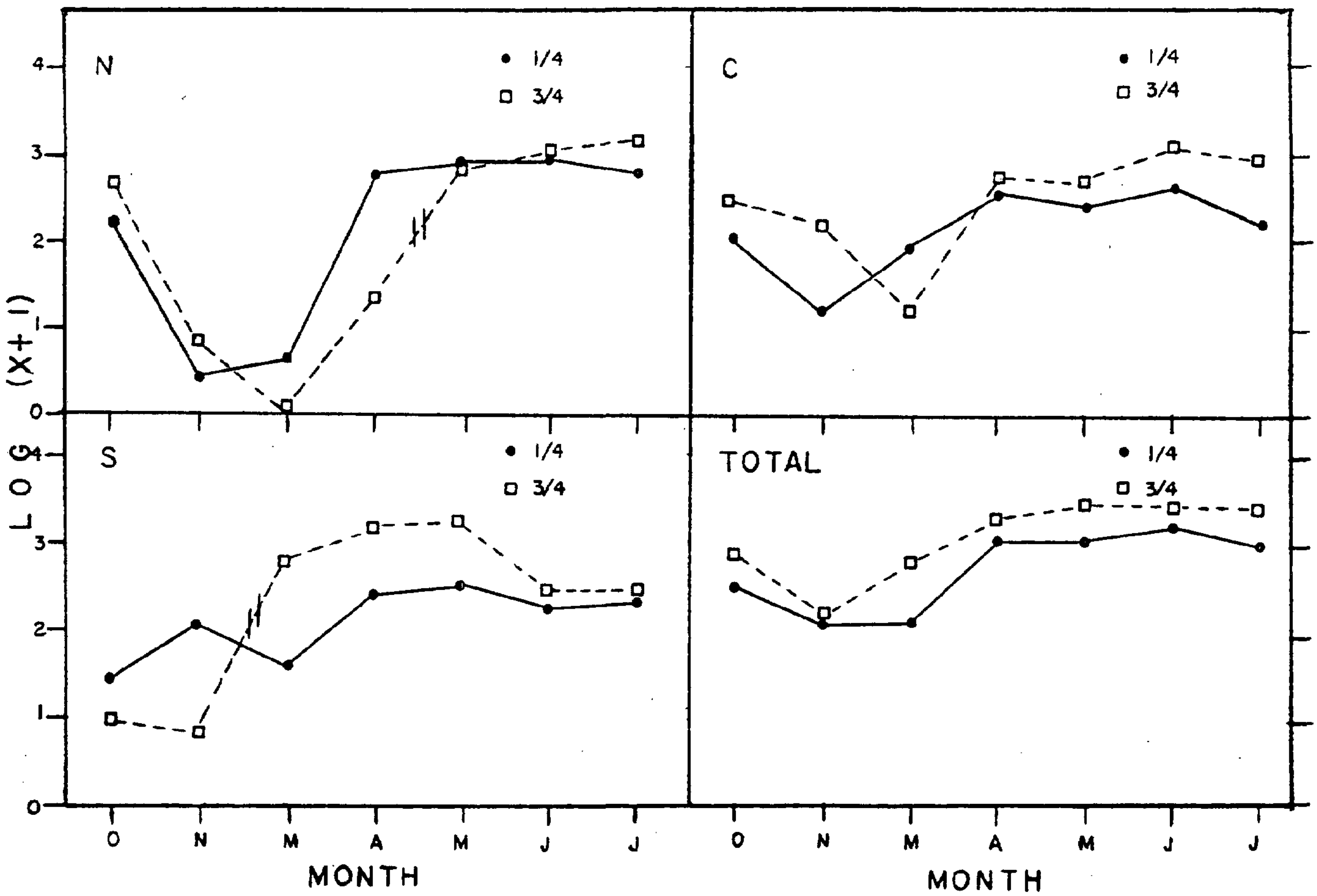

Figure 21. Seasonal abundance of *Micropogonias undulatus* in primary (1/4") and secondary (3/4") trawl stations in North Carolina during October and November, 1980 and March-July, 1981. N=northern area, C=central area, S=southern area. Addition of 1/4" mesh tail bag to the 3/4" trawl denoted by "//".

central areas generally increased as the season progressed, while those in the shallows decreased. This inverse relationship and shifts in length frequency modes indicated migration from the primary areas began in late spring/early summer.

Croakers were consistently less abundant in primary stations of the northern and central areas during 1981, relative to 1979 and 1980 (Table 6). Catches in the southern area varied sporadically. Increased catches in the secondary areas reflected the use of a smaller mesh tail bag.

Paralichthys lethostigma (Jordan and Gilbert)-Southern flounder

Southern flounder is one of the most common paralichthid flounders found in North Carolina estuarine waters. The Albemarle Sound area is the northern limit of the species' range, which extends as far south as Texas (Ginsberg 1952 in Powell 1974). Southern flounder spawn during fall and early winter (Smith et al. 1975). Postlarvae enter North Carolina estuaries during the winter (Deubler 1958, Tagatz and Dudley 1961, Williams and Deubler 1968b). Juveniles seek nursery grounds characterized by low salinities and muddy substrates. Movement out of estuarine waters is thought to begin after the juvenile flounder become yearlings (Powell and Schwartz 1977). Various ages of adult southern flounder also utilize North Carolina's estuaries. Significant pound net fisheries have developed to exploit adults during fall migrations from the estuaries (Wolff 1977, DeVries 1981).

Southern flounder was the most common flounder captured (1,297 individuals) during the study period. Southern flounder were captured in all three regions, but were not abundant anywhere, representing a maximum of 0.4% of the total finfish catch in each area. Carpenter (1979) and Ross (1980, in press) also found similar distributions and general abundances during previous studies in North Carolina.

Southern flounder young-of-the-year were first captured in estuarine waters during March, at a size range of 10-40 mm TL (Figure 22). Young juveniles evidently sought the upper reaches of tributaries during recruitment since juveniles were captured in open water stations until April and then very few were observed. Peak southern flounder abundance occurred during April in all three areas (Figure 23), when young-of-the-year dominated upper tributary flounder catches at a size range of 18-65 mm TL. Relatively high abundances of new recruits were also noticed during March in

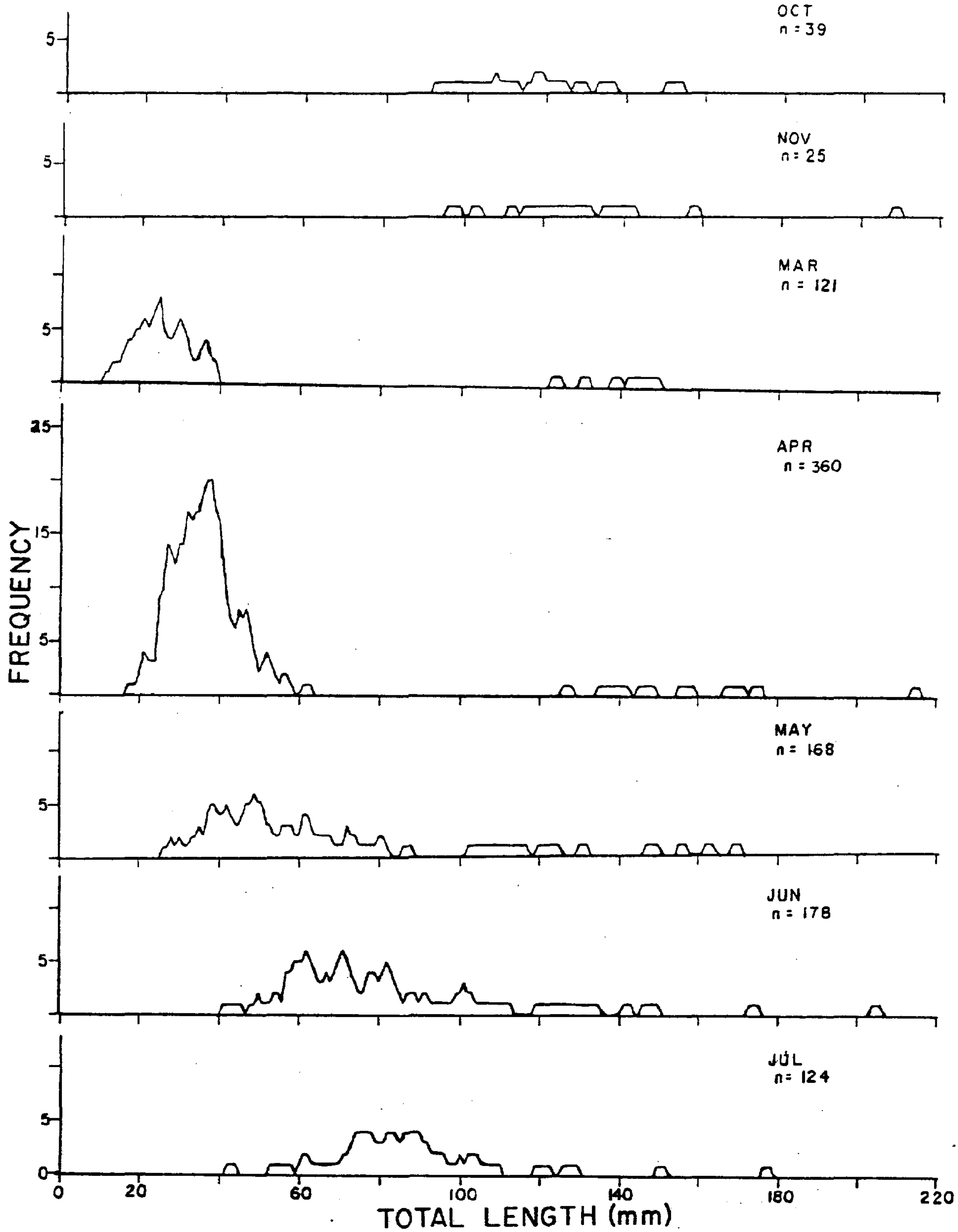

Figure 22. Length frequencies of *Paralichthys lethostigma* captured in primary stations in North Carolina (October and November, 1980 and March - July, 1981).

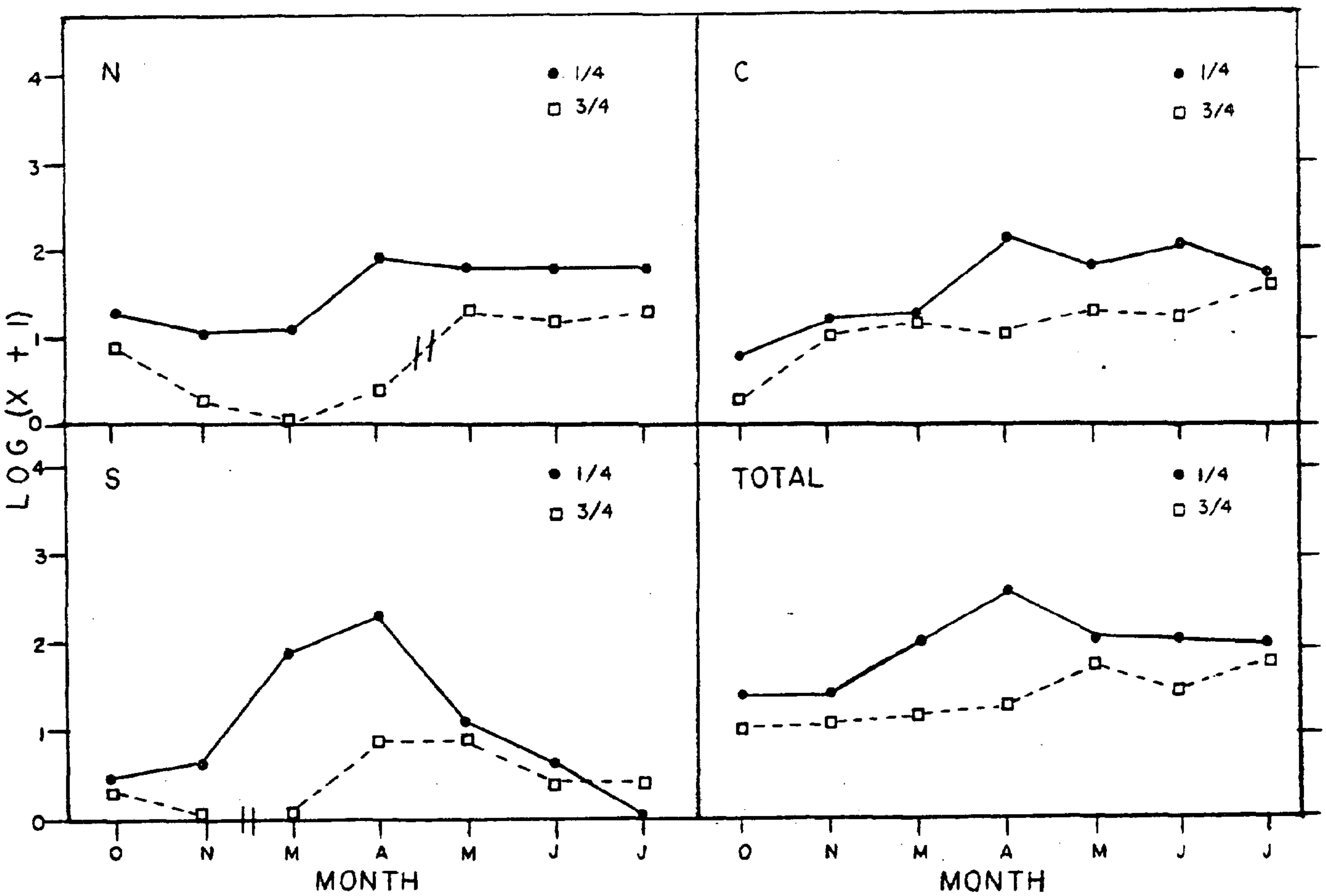

Figure 23. Seasonal abundance of *Paralichthys lethostigma* in primary (1/4") and secondary (3/4") trawl stations in North Carolina during October and November, 1980 and March-July, 1981. N=northern area, C=central area, S=southern area. Addition of 1/4" mesh tail bag to the 3/4" trawl is denoted by "//".

the southern area. Juvenile southern flounder utilized the areas of the coast differently. Southern flounder numbers decreased rapidly in the southern area after April; the fish completely migrated out of the upper creeks by July. A few individuals remained in open waters. Weinstein (1979) and Ross (1980, in press) also found peak juvenile abundance in the southern area during March and April, and rapidly declining numbers thereafter. Flounder in the northern and central areas utilized the shallow tributaries through July, with numbers generally decreasing as the season progressed (Figure 23). Purvis (1976) and Ross (1980, in press) found similar occurrences.

Several year classes of southern flounder utilized North Carolina estuarine tributaries (Figures 22 and 24). Two size classes of flounder were captured during March and April in both the upper creeks and more open waters. The smallest size group represented young-of-the-year. The larger individuals represented yearlings according to size and age compositions reported by DeVries (1981). Juveniles approaching one year in age were taken in October and November according to length frequency data (60-160 mm TL). Powell and Schwartz (1977) estimated southern flounder juveniles reached 130 mm TL by the end of their first year (December); 90-100 mm TL individuals, caught in the spring, represented extremely fast growing young-of-the-year juveniles that were recruited in early winter. They concluded that growth ceased by autumn and did not resume until spring, when the fish were age 1. The southern flounder age and growth observations of this study and of DeVries (1981) differed considerably from those of Powell and Schwartz (1977). These data indicated that the 90-100 mm TL specimens caught in the spring were probably slow growing juveniles, recruited the previous winter and spring, and were already age 1. The apparent growth cessation noticed by Powell and Schwartz (1977) during the fall was possibly caused by the migration of smaller fish into open waters, where most of the investigators' stations were located. Powell and Schwartz (1977) also utilized sampling gears selective for larger individuals.

Different length-frequency modes were discernible for juveniles and yearlings during March through May, but were difficult to distinguish in June and July. Therefore, length estimates present a very general approximation of growth. Growth estimates for early spring indicated that flounder from the southern area were slightly larger than those from the central and northern areas, probably due to earlier recruitment of individuals into the region. Weinstein (1979) presented

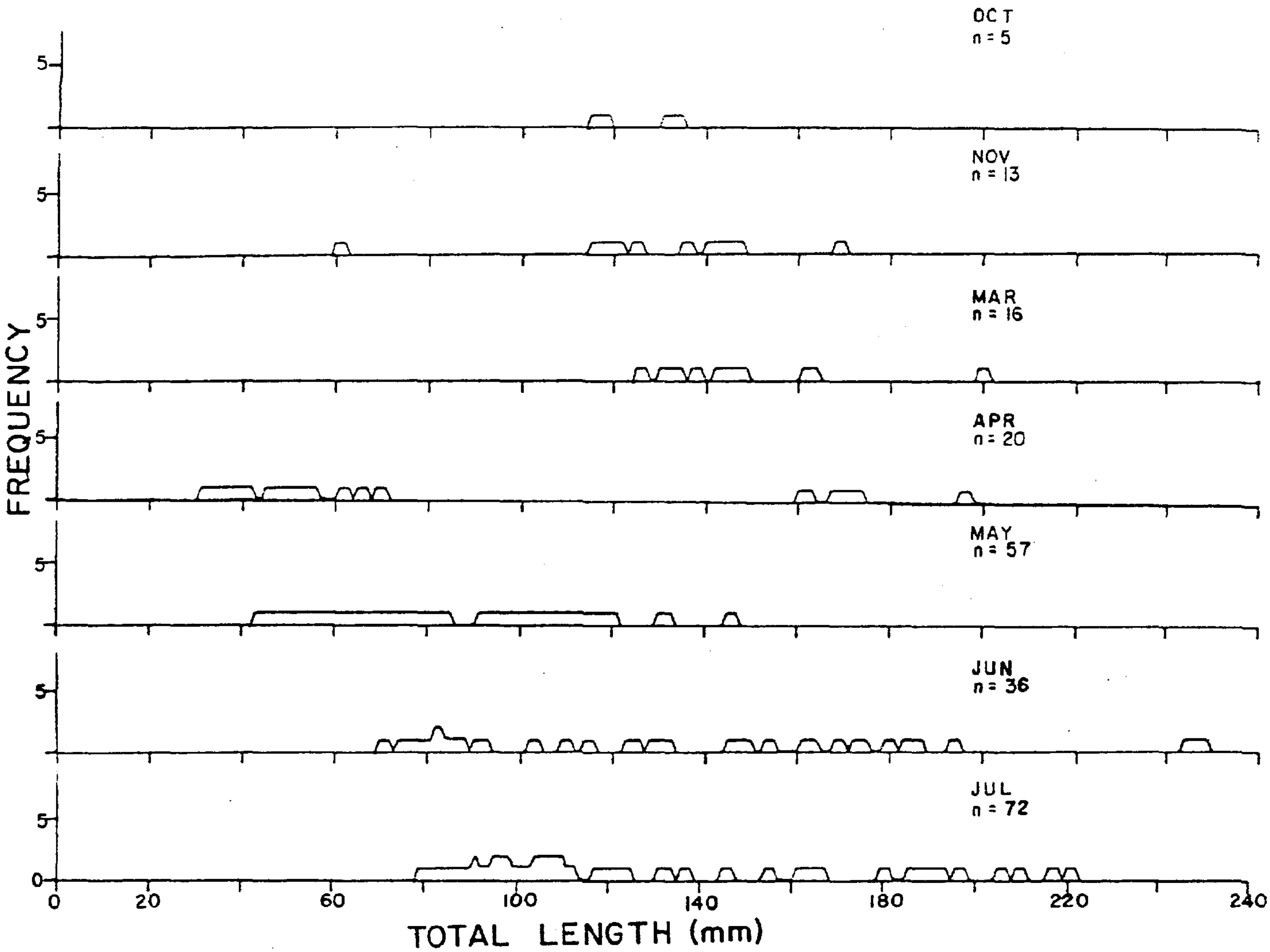

Figure 24. Length frequencies of *Paralichthys lethostigma* captured in secondary stations in North Carolina (October and November, 1980 and March-July, 1981).

length data on southern flounder in the Cape Fear region for February through April, finding smaller fish than those captured in this study. Larger flounder were captured coastwide during March through July, 1981 when compared with length frequencies from similar areas and times during 1979 and 1980 (DeVries 1981).

INVERTEBRATES

Total Catch Composition

Although most juvenile estuarine surveys have concentrated on finfish populations, investigators have also noted large numbers of mobile invertebrate species in shallow estuarine creeks and marshes (Hackney et al. 1976, Carpenter 1979, and Baisden 1979). Species reported in the southeastern United States have primarily been penaeid and caridean shrimps and the blue crab (*Callinectes sapidus*). The present study collected 23 species of invertebrates (Table 7), with almost 94% of the total invertebrate catch represented by penaeid shrimp and blue crabs. Species composition during 1981 was very similar to a previous North Carolina study during 1978 (Carpenter 1979), except relatively few shrimp (*Palaemonetes spp.*) were collected. Brown shrimp (*Penaeus aztecus*) was the most common penaeid shrimp captured, accounting for 81% of the commercially-important shrimp catch. Pink shrimp (*P. duorarum*) was second in abundance, representing 11% of the coastwide totals. Blue crabs were the most abundant invertebrate in the samples, representing almost 43% of the total invertebrate catch.

Interregion Comparisons

The southern area contained the largest number of invertebrate species. This phenomenon was probably due to the proximity of the area's estuaries to the Atlantic Ocean. The same characteristics which allowed the area to support relatively more fish species also hold true for invertebrates: extensive tidal action over a generally limited area provides easy transport to marshes and creeks and also maintains higher salinities. Warmer winter water temperatures may also contribute to greater diversity. The northern and central areas appeared to support similar species, and together differed noticeably from the southern region's species composition. Catches from the southern area contained higher

[redacted]

Table 7. Total numbers and size range[1] of invertebrates captured during North Carolina estuarine monitoring program (all stations combined) for October-November, 1980 and March-July, 1981.

	Areas											
	Northern				Central				Southern			
	1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl	
Species	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range
Class Cephalopoda												
Order Decapoda												
Loligo spp. (squid)	5	-	46	-	2	-			51	-	132	-
Class Crustacea												
Order Stomatopoda												
Squilla empusa (mantis shrimp)					1	130			2	17-38	12	14-128
Order Mysidacea												
Neomysis americanus									54	12-19		
Order Decapoda												
Family Penaeidae												
Penaenus setiferus (white shrimp)	38	38-95	15	65-135	231	25-125	24	45-135	119	45-135	182	65-145
P. duorarum (pink shrimp)	173	15-105	5	45-109	142	25-145	20	85-135	404	25-125	89	45-135
P. aztecus (brown shrimp)	754	15-151	1,317	45-136	1,251	15-155	372	55-155	1,745	15-145	807	35-145
Trachypenaeus constrictus									13	19-41	7	31-59
Family Sergestidae												
Acetes americanus									22	15		

Table 7. (continued).

Species	Areas											
	Northern				Central				Southern			
	1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl	
	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range
Family Palaemonidae												
Periclimenes longicudatus									20	15-19		
Palaemonetes vulgaris									5	35		
P. intermedius									92	18-37		
P. pugio									188	17-34	17	24-32
P. spp. (shore shrimp)	96	25			65	25-42						
Family Alpheidae												
Alpheus heterochaelis (pistol shrimp)									3	37-38	1	32
A. spp. (snapping shrimp)					1	65						
Family Portunidae												
Ovalipes ocellatus (spotted lady crab)									1	33		
O. quadulpensis (lady crab)									13	24-33		
Portunus gibbesi									27	34-85		
Callinectes sapidus (blue crab, male)	998	5-175	698	15-185	928	5-163	692	10-92	314	5-165	143	15-175
C. sapidus (blue crab, female)	517	4-163	489	15-185	514	5-155	493	18-175	73	25-155	189	25-165
C. sapidus (sex unknown)	343	4-28			5	6-15						

[redacted]

Table 7 . (continued).

Species	Areas											
	Northern				Central				Southern			
	1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl		1/4" trawl		3/4" trawl	
	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range	N	Size range
Family Xanthidae												
Rhithropanopeus harrisii (riff crab)	12	5-22	2	20-21								
Neopaneope texana sayi									13	24-23		
Family Majidae												
Mithrax hispidus (coral crab)											3	12-16
Total no species	9				10				21			

[1]Sizes reported in total length (mm) for shrimp (tip of carapace to tip of rostrum) and in carapace width (mm) for crabs. Squid were not measured.

numbers of stomotopods, mysid shrimps, sergestid shrimps, shore shrimps (*Periclimenes spp.*), snapping shrimps (*Alpheus spp.*), lady crabs *Ovalipes spp.*), and coral crabs (*Mithrax hispidus*). Brown shrimp was the major invertebrate caught in the southern area, while blue crabs dominated the northern and central catches (Table 8). Pink and white (*P. setiferus*) shrimps also occurred more commonly in trawl samples from the southern area than in those from the northern and central regions, perhaps reflecting preferences for higher salinity habitats (Williams 1965).

Past investigations have also found brown shrimp to be the most abundant penaeid shrimp in North Carolina estuarine waters (Spitsbergen and Wolff 1974, Purvis 1976, Weinstein 1979). The higher numbers of juvenile brown shrimp are reflected in the species' importance in North Carolina's major commercial shrimp. Pink shrimp were second in commercial shrimp abundance in catches from the northern and southern areas. Previous studies have shown that pink shrimp usually reach their highest numerical peak in the estuarine tributaries of North Carolina during late summer and early fall (Williams 1955, Spitsbergen and Wolff 1974, Purvis 1976). The sampling period covered by this study did not include this period. Also, Purvis (1976) noted sampling difficulties encountered with pink shrimp due to their nocturnal habits. White shrimp also reach peak numbers during late summer/early fall (Williams 1955, Carpenter 1979); therefore, the same seasonal sampling limitations apply to this species.

Unlike previous studies by Spitsbergen and Wolff (1974), Purvis (1976), and Carpenter (1979), blue crabs represented the major portion of the invertebrate catch in the northern and central areas during 1981 (Table 8). These areas provide the vast majority of North Carolina's commercial crab harvest.

Major Species

Three species of penaeid shrimps and the blue crab were chosen for discussion because of their commercial importance and relatively high abundance. Length frequency and abundance data are presented in similar fashion as previous fish data.

Penaeus aztecus (Ives)-Brown shrimp

Spawning of brown shrimp takes place offshore during late winter and early spring (Williams and Deubler 1968b). Williams (1969) found young brown shrimp

Table 8. Total numbers and percent of total catch by area for commercial invertebrates captured by trawl in North Carolina estuarine waters, October - November, 1980 and March - July, 1981.

	Areas					
	Northern		Central		Southern	
Species	N	Percent of area's total number	N	Percent of area's total number	N	Percent of area's total number
Penaenus setiferus	53	1.0	255	5.4	301	6.3
P. duorarum	178	3.2	162	3.4	493	10.3
P. aztecus	2,071	37.6	1,623	34.2	2,552	53.4
Callinectes sapidus	3,045	55.3	2,632	55.4	719	15.1
Total number	5,508		4,748		4,775	

postlarvae moving through several North Carolina inlets into estuarine waters from January through May, with the largest numbers found in March. Subsequent studies also noted spring recruitment (Purvis 1976, Carpenter 1979, Weinstein 1979). Postlarval brown shrimp migrate to brackish creeks, characterized by soft bottoms and usually covered with dissolved forest litter (Williams 1955). Brown shrimp juveniles prefer salinities greater than 10 ppt in North Carolina waters (Carpenter 1979, Jones and Sholar 1981). Brown shrimp grow rapidly (1-1.5 mm/day) in estuarine tributaries (Williams 1955, McCoy 1968). The shrimp migrate out of estuarine areas toward the ocean as they become larger. Spitsbergen and Wolff (1974) and Purvis (1976) noted migration from the shallow tributaries when brown shrimp reach 95 mm. Brown shrimp usually leave North Carolina estuarine waters by late fall.

The present investigation collected 6,246 brown shrimp. The species was collected throughout the study period, except during March, and ranged in size from 15 mm during April, 1981 to 155 mm during November 1980. Brown shrimp recruitment for 1981 began during April in the southern area and early May in the central and northern areas (Figure 25). Temperatures during recruitment ranged from 15 - 28°C in all three regions and salinities, from 0 to 33 ppt. Williams and Deubler (1968b) reported most postlarval brown shrimp in North Carolina waters recruited during temperatures between 11 and 22°C and were found at salinities of 0.1-34.8 ppt.

The highest numbers of brown shrimp were captured in the southern area, with peak abundances occurring in the shallow tributaries during May at 15 to 95 mm. Peak numbers in the southern area's secondary stations were found a month later at 55 to 125 mm and declined rapidly thereafter. Weinstein (1979) and Carpenter (1980) found the highest numbers of brown shrimp in the southern area during May in shallow water habitats.

Peak brown shrimp numbers in the northern and central areas' primary stations did not occur until June. Shrimp sizes during June ranged from 25 to 129 mm. Previous studies have shown that peak abundance periods in the shallow tributaries of Pamlico Sound are variable, occurring between May and July, depending upon the year and the location (Williams 1955, Purvis 1976, Jones and Sholar 1981). The highest number of brown shrimp in the secondary stations of the central area were noted during June (Figure 25). Peak abundances in the open water stations in the northern area did not occur until July and were accompanied by a decrease in catches from the upper stations. Shrimp captured in the secondary areas were a combination of juveniles and

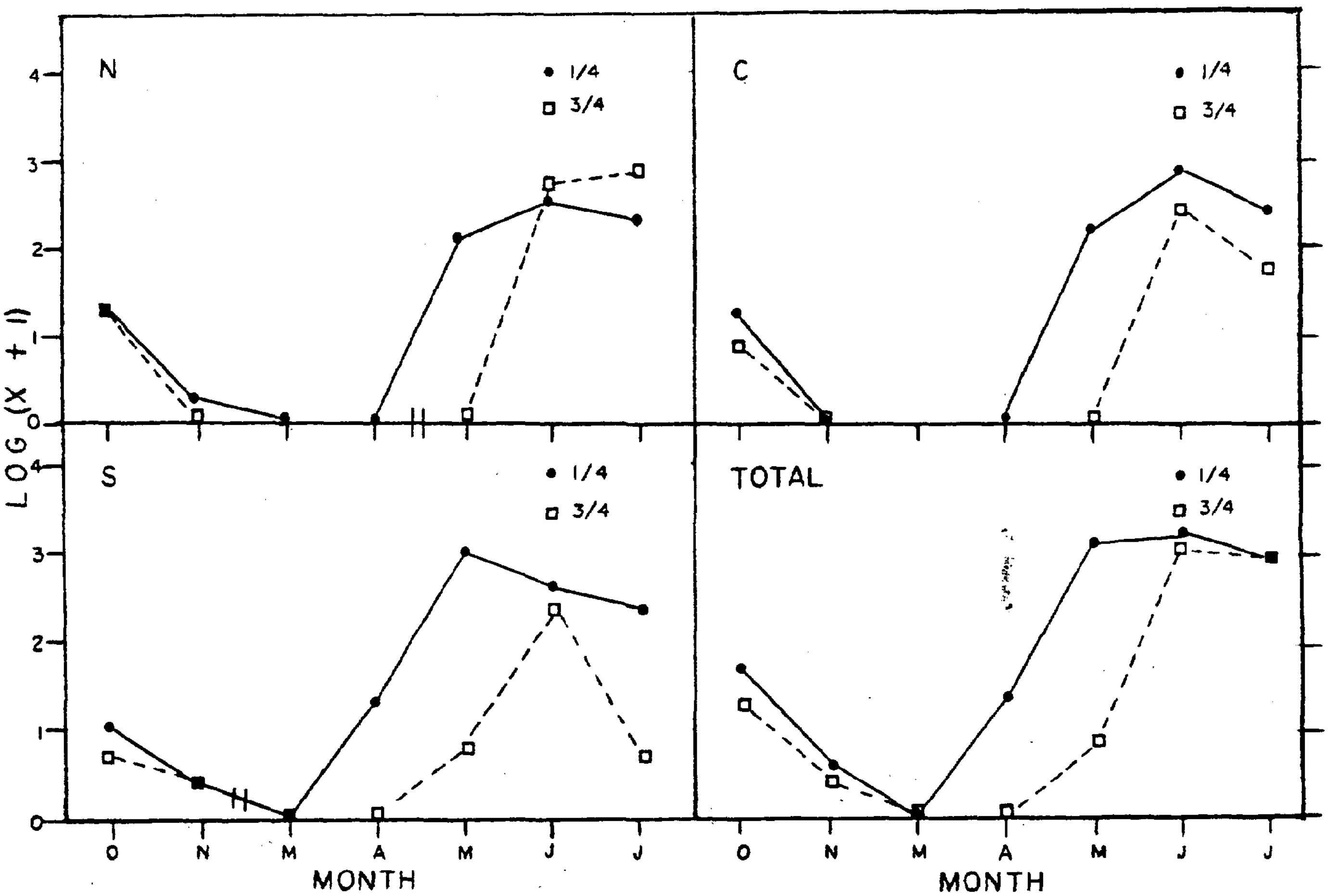

Figure 25. Seasonal abundance of *Penaeus aztecus* in primary (1/4") and secondary (3/4") trawl stations in North Carolina during October and November, 1980 and March-July, 1981. N=northern area, C=central area, S=southern area. Addition of 1/4" mesh tail bag to the 3/4" mesh trawl is denoted by "//".

adults, ranging from 47 to 136 mm in size. Spitsbergen and Wolff (1974), Purvis (1976), Carpenter (1980) and Jones and Sholar (1981) observed high numbers of brown shrimp remaining in estuarine tributaries of Pamlico Sound until August. Brown shrimp were abundant in this investigation through July. Lowest brown shrimp numbers were encountered in the fall of 1980 due to migration out of the estuaries.

Penaeus duorarum (Burkenroad)-Pink shrimp

Pink shrimp is the only penaeid shrimp which overwinters in significant quantities in North Carolina's estuarine waters. Depending on winter conditions, large numbers of juveniles and sub-adults may overwinter in the relatively muddy bottoms of northern and western Pamlico Sound and the sandy/grassy bottoms of Core Sound and the Outer Banks (Williams 1955, Purvis and McCoy 1972, Wolff 1976). Surviving shrimp move out of their overwintering burrows as water temperatures reach 15^{o}C or greater in the spring (Williams 1955, Purvis and McCoy 1972). Survivors support the spring/early summer pink shrimp fishery of Pamlico and Core sounds (Purvis and McCoy 1972). Growth is rapid (13 mm/week) once water temperatures increase (Williams 1955). Young adults begin maturing during May. By late June, the majority are usually sexually mature and have migrated to the Atlantic Ocean. Most postlarval recruitment occurs in North Carolina waters during May through August, varying annually and among localities (Williams 1955, Spitsbergen and Wolff 1974, Purvis 1976, Weinstein 1979). Recruitment does continue into late November, which is indicative of a protracted spawning period.

Pink shrimp were captured throughout the study period in the southern region and captured in all months except March and July in the northern and central areas. The shrimp ranged from 15 to 135 mm. Abundance graphs generally exhibit the pink shrimp estuarine utilization cycle in North Carolina waters (Figure 26). Two abundance peaks are noted for the state: the first one in October and November, when both adults and sub-adults (75-135 mm) are present in estuarine waters just before overwintering and the second during April, when small shrimp were first observed in Pamlico Sound and recruitment appeared well underway in the southern region. March water temperatures during the recruitment period of the southern area ranged from 10 to 16^{o}C. April water temperatures for all areas ranged from 15.9^{o}C to 25^{o}C.

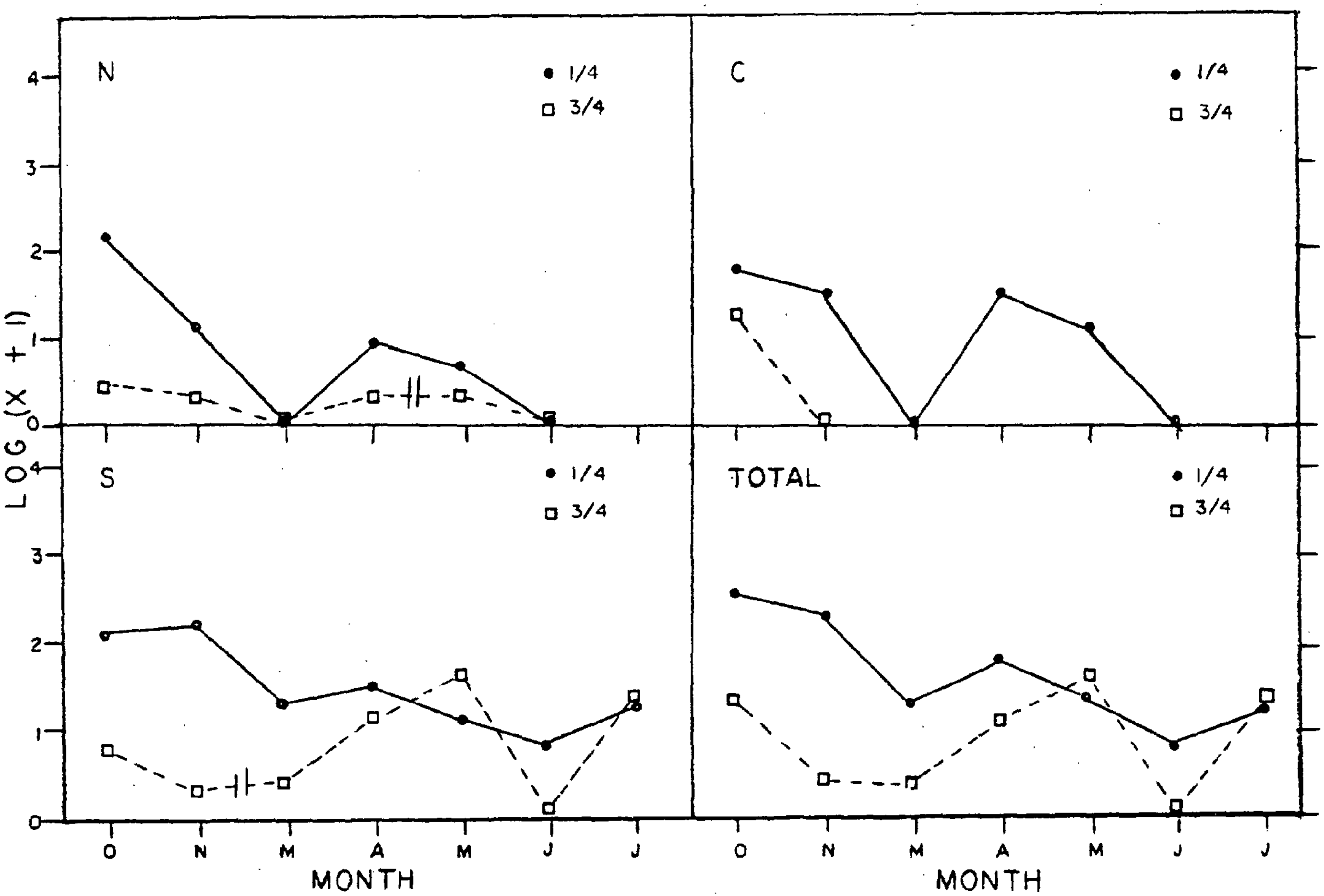

Figure 26. Seasonal abundance of *Penaeus duorarum* in primary (1/4") and secondary (3/4") stations in North Carolina during October and November, 1980 and March-July, 1981. N-northern area, C=central area, S=southern area. Addition of 1/4" mesh tail bag to the 3/4" trawl is denoted by "//".

Pink shrimp were most abundant in trawl catches from the southern area. Peak abundance was noted in the upper creek stations during fall, at a size range of 25 to 75 mm. The highest numbers in the open water stations were recorded during May, when the shrimp were 85-135 mm in length. Carpenter (1980) also observed peak abundance in the southern area's shallow stations during May; however, Weinstein (1979) found that abundances in the Cape Fear area peaked in July and declined afterwards. The greatest numbers in the northern and central areas' upper stations occurred during fall, agreeing with previous investigations in Pamlico Sound (Spitsbergen and Wolff 1974, Purvis 1976, Carpenter 1980). Shrimp in these areas varied tremendously in size, ranging from 15 to 135 mm. Juvenile numbers in the upper tributaries again reached a maximum during April, a result of either new recruitment in 1981 or overwintering juveniles from the fall of 1980. Pink shrimp were not abundant anytime in the northern and central areas during March through July 1981, supporting previous observations of Spitsbergen and Wolff (1974) Purvis (1976), and Carpenter (1980).

Penaeus setiferus (Linnaeus)-White shrimp

The least common penaeid shrimp occurring in North Carolina is the white shrimp. Spawning of white shrimp in North Carolina takes place offshore during May through September, with postlarvae and small juveniles first appearing in estuarine waters during June (Williams 1959, Spitsbergen and Wolff 1974). Recruitment usually extends through September, with peak numbers occurring in July, August, or early September (Williams 1955, Weinstein 1979, Carpenter 1980). Juvenile growth is rapid (36 mm/month) upon entering the shallow tributaries (Williams 1955). As the shrimp reach the sub-adult stage, growth slows considerably (12 mm/month) and movement is initiated toward open waters (McCoy and Brown 1967). Most of the white shrimp move out of estuarine waters by November. A small portion of the population overwinters in the southern region (Carpenter 1980).

Only 609 white shrimp were captured during the study period, ranging in size from 25 to 145 mm. Recruitment was first observed during June in the southern area, and a month later in the central and northern areas. Small shrimp (less than 35 mm) were also noted during October, 1980 in the central area. Peak numbers were observed in the central and southern areas during fall at 25 to 145 mm, and during the initial recruitment period in the northern area, at 38 to 54 mm. Copeland and Birkhead (1972) also found peak numbers in the fall for the southern area, while Weinstein (1979) found both initial recruitment and high abundances during July. Spitsbergen and Wolff (1974) and Purvis (1976) reported high numbers during the fall for western and northern Pamlico Sound. The present investigation terminated before white shrimp peak abundances normally occur in each respective region (July - September). Juvenile shite shrimp (8) were captured in the northern and western tributaries of Pamlico Sound during March, a phenomenon previously unreported. The shrimp ranged in size from 45 to 85 mm. This occurrence may indicate isolated juvenile overwintering in Pamlico Sound or an unusual seasonal recruitment into Pamlico Sound during 1981.

Callinectes sapidus (Rathburn)-Blue crab

Blue crabs are one of the most important commercial estuarine resources along the Atlantic coast. The major fishing areas are Chesapeake Bay, Pamlico Sound, and the St. Johns River, Florida. Blue crab mating occurs in brackish water between May and October (Van Engel et al. 1973). Females mate once, but males may mate several times. After mating, females migrate to higher salinity waters near inlets. The male blue crabs usually remain in brackish tributaries and overwinter in muddy substrates when water temperatures decline in early winter. Females spawn in higher salinity waters during spring through fall after mating (Van Engel et al. 1973). Individuals potentially spawn several times during the season and some females may also spawn the next year after overwintering in the sediments near the inlets. In North Carolina, tagging studies have indicated that some females move back to estuaries after spawning in the ocean (Judy and Dudley 1970). Hatched larvae migrate or are carried offshore by currents (Nichols and Keney 1963, Dudley and Judy 1973). About six months after hatching, the juvenile crabs migrate back to the brackish estuaries, where they grow to maturity (Dudley and Judy 1973).

A total of 6,396 blue crabs were captured during the study period, ranging in size from 4 to 185 mm for males and 5 to 185 mm for females. Length frequencies of male and female blue crabs captured in the primary and secondary stations of Pamlico Sound during March through July are presented in Figures 27-30. Exact lengths were not taken in October and November, 1980, preventing use of fall data for length frequency analysis. Abundance by sex in the shallow creeks and deeper waters for each region are shown in Figure 31. Abundances of new recruits (crabs less than 40 mm) are also graphed in Figure 31.

Blue crabs were abundant everywhere and were captured during all months. Abundance data indicated continuous recruitment. Crabs less than 40 mm were most abundant in catches during April, but only decreased slightly thereafter. Blue crab juvenile recruitment has been noted to exhibit two peaks in Pamlico Sound: one during August through November, and the other during March through May (Dudley and Judy 1973; Carpenter 1979, 1980; DeVries 1981). Large quantities of small blue crabs were also noted in this study during October and November. Small recruits were most evident in abundance plots for males in the northern area (Figure 31).

Abundance of male blue crab remained high in the primary areas' catches through spring in all regions. A decline in catches was not observed until June. The majority of males captured were less than 30 mm through May. Apparent movement of male recruits into open waters was noted in June and July, when large increases in the number of blue crabs greater than 50 mm were observed (Figure 28). Male blue crabs were more abundant in the secondary areas during June (central area) and July (northern area) than in the shallow tributaries, and represented significant increases over the numbers found during March through May in the deeper waters.

Female blue crabs were generally less abundant than males in all areas. Females increased slightly in number from March through June in the primary stations. Female blue crabs in those areas usually were less than 40 mm (Figure 29). Abundances in the secondary stations increased steadily in the northern and central areas as spring progressed. Females became more numerous in the open waters, relative to the shallows, during June in western Pamlico Sound and July, in northern Pamlico Sound. The increase was due to higher catches of 40 to 80 mm crabs in June and 50 to 120 mm crabs in July (Figure 30). Female blue crabs in the southern area were more abundant in the open waters throughout spring, a phenomenon also reported by Carpenter (1980).

The results of this study agree with the observations of Dudley and Judy (1973). Juvenile blue crabs usually recruit and peak in number during late

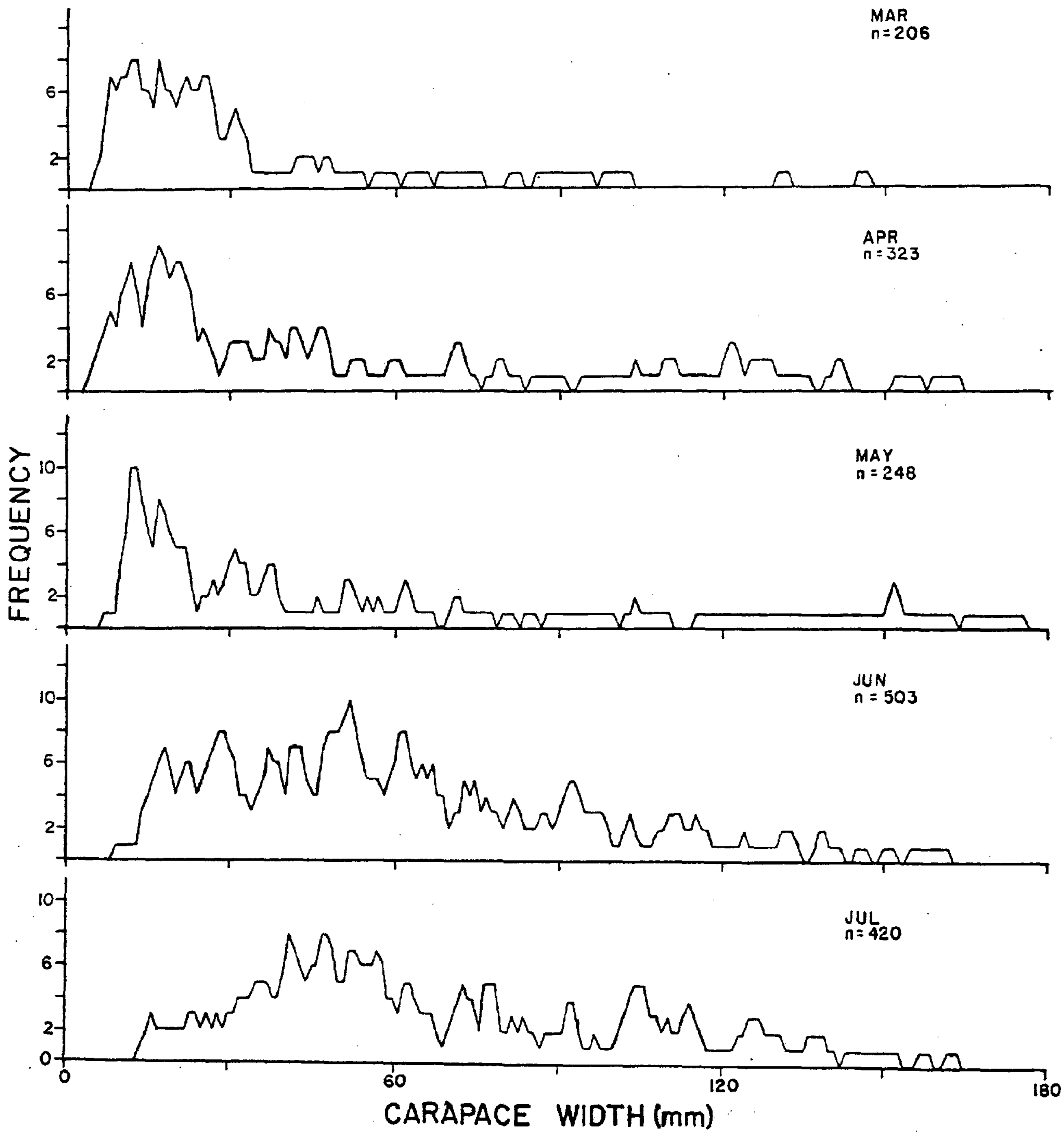

Figure 27. Size frequencies of male *Callinectes sapidus* captured in primary stations in North Carolina (March-July, 1981).

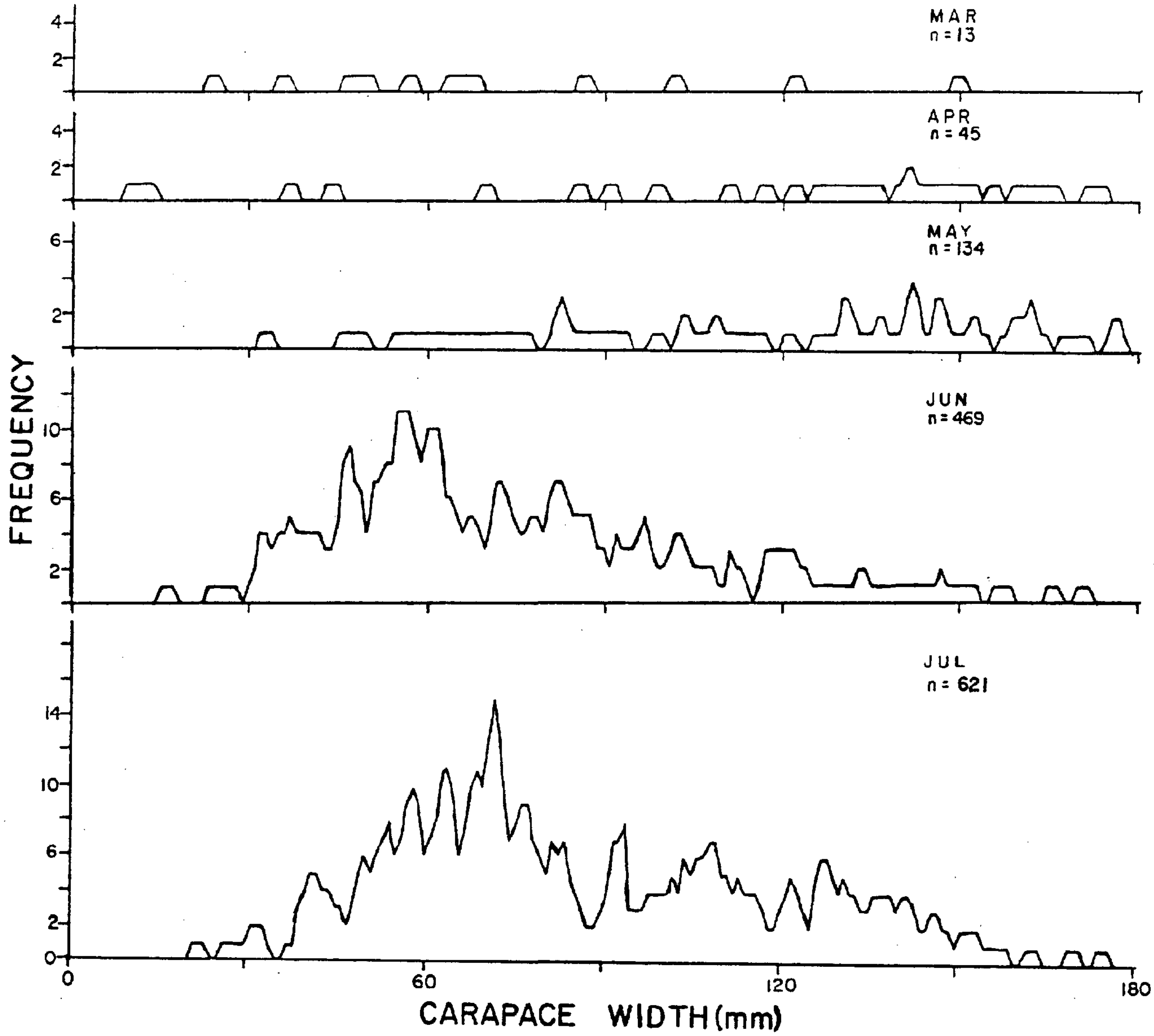

Figure 28. Size frequencies of male *Callinectes sapidus* captured in secondary stations in North Carolina (March-July, 1981).

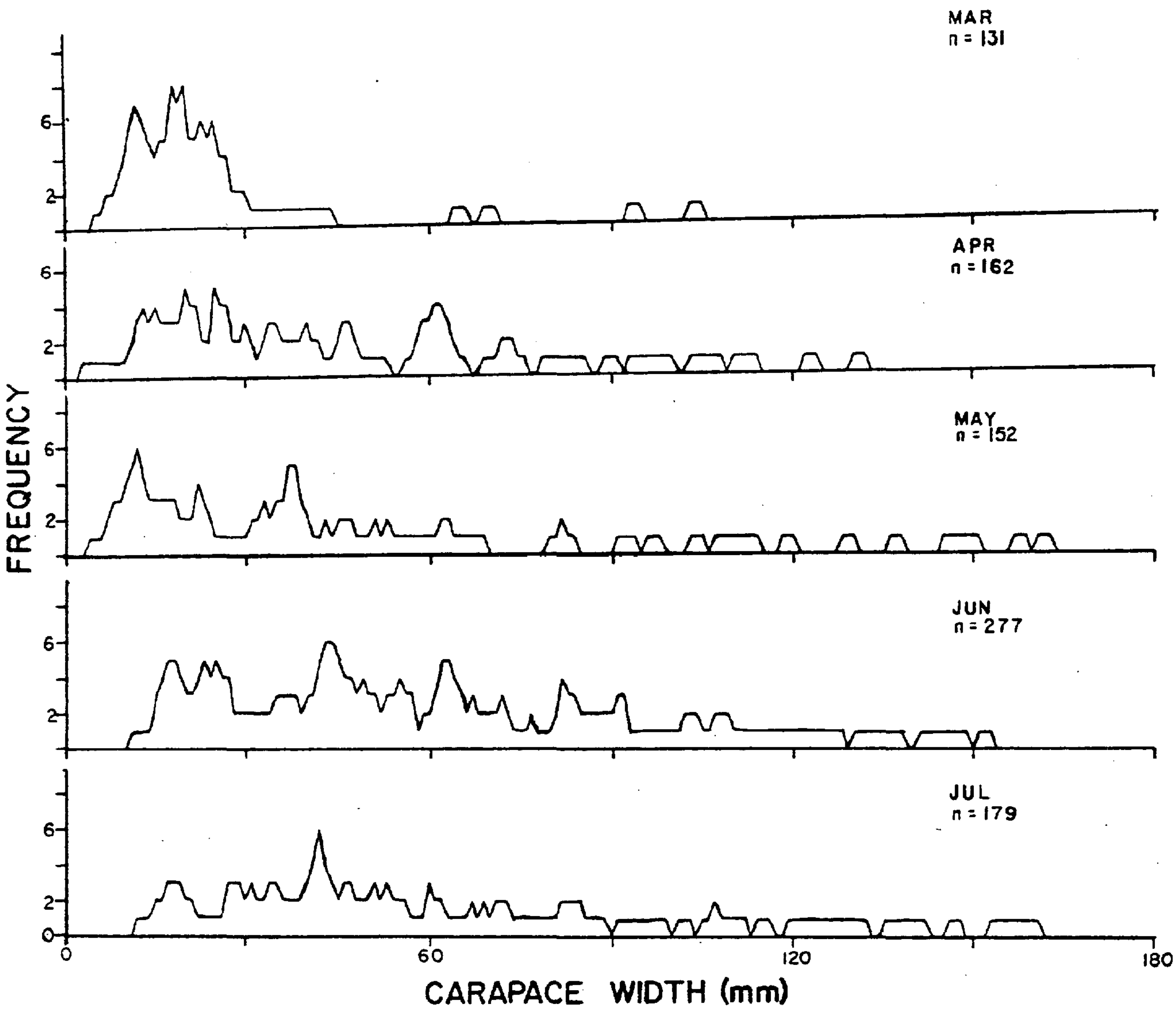

Figure 29. Size frequencies of female *Callinectes sapidus* captured in primary stations in North Carolina (March-July, 1981).

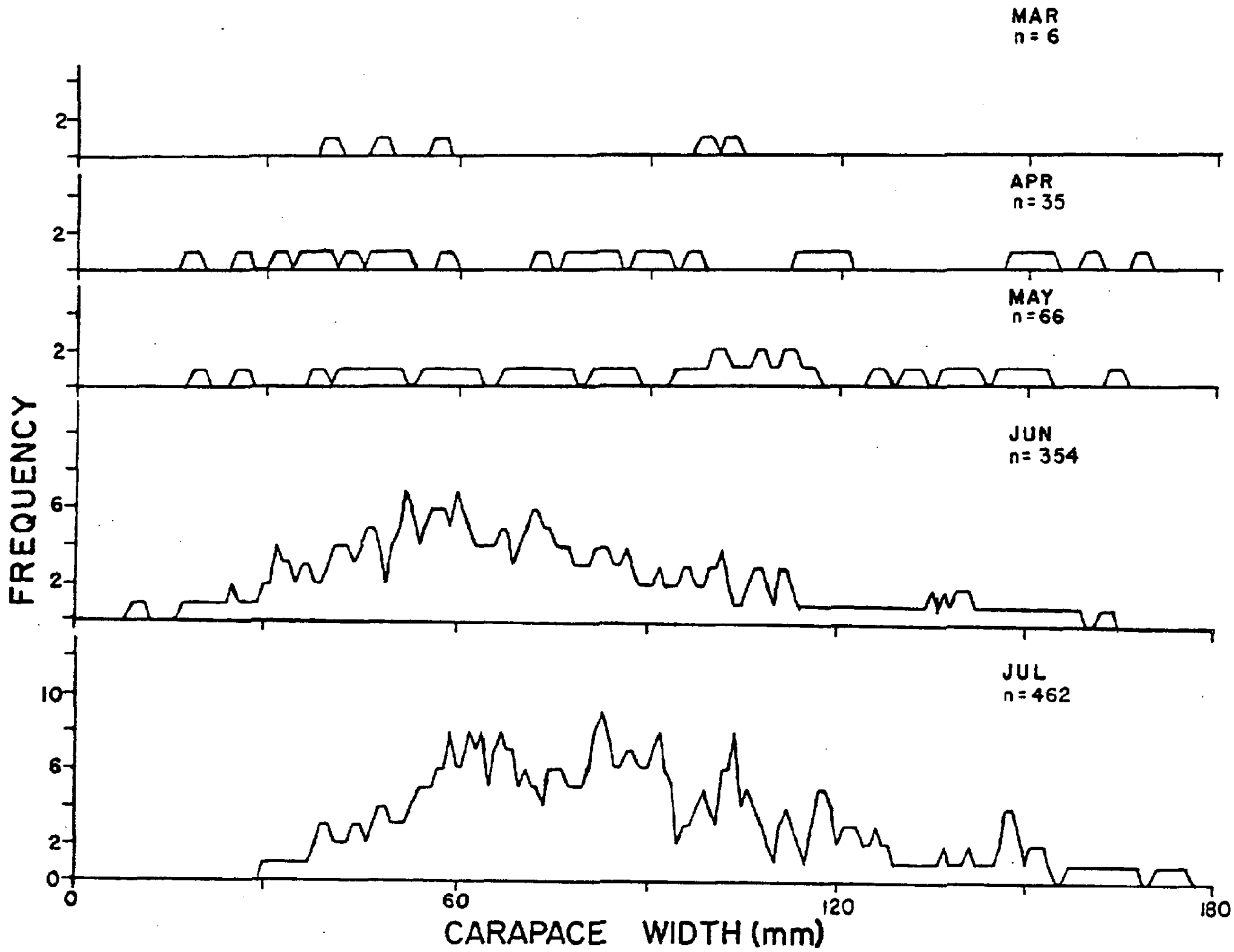

Figure 30. Size frequencies of female *Callinectes sapidus* captured in secondary stations in North Carolina (March-July, 1981).

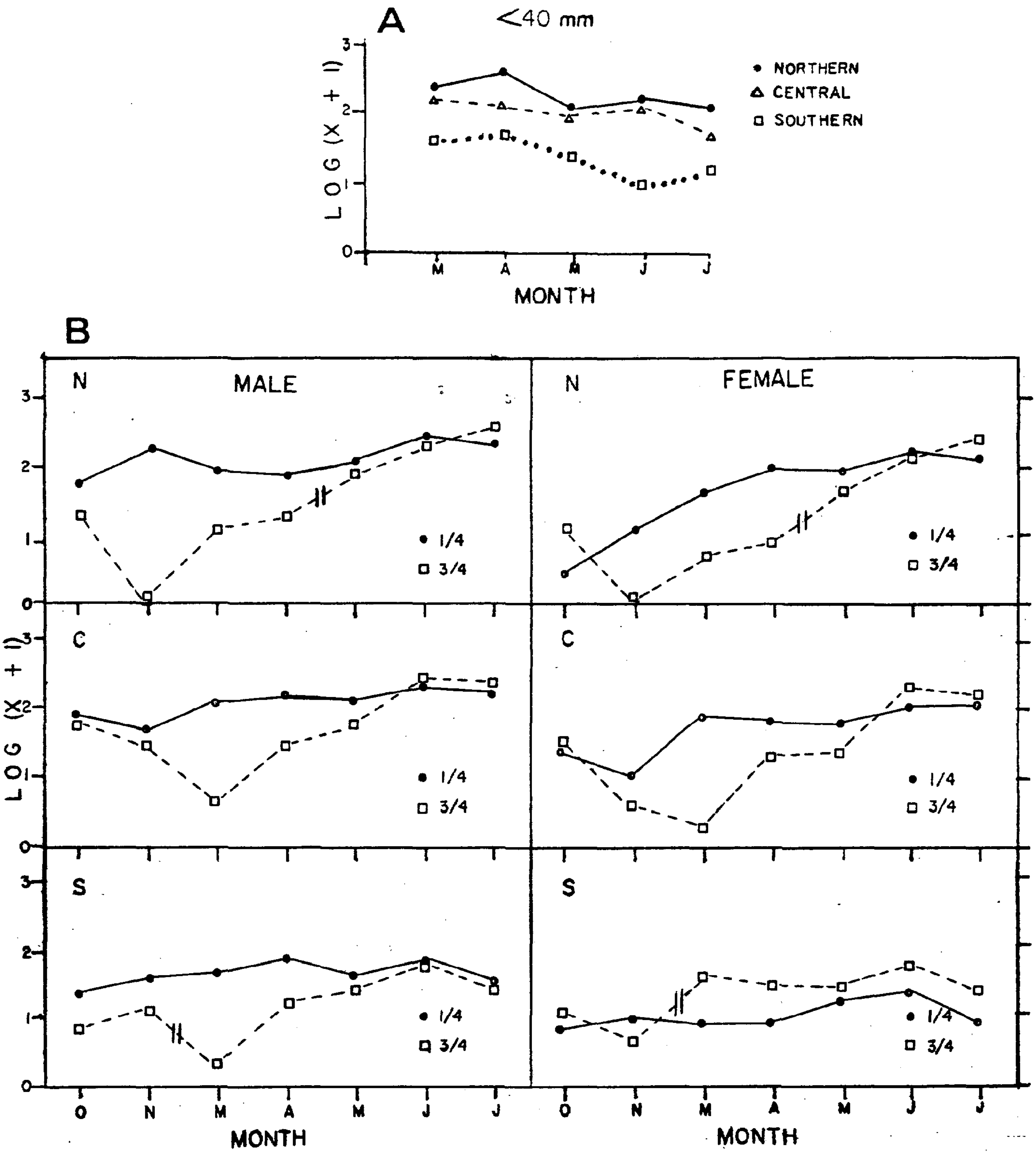

Figure 31. A. Seasonal abundance of *Callinectes sapidus* recruits (less than 40 mm) in the northern, central, and southern study areas of North Carolina, March-July, 1981 (all stations combined).

B. Seasonal abundance of male and female *C. sapidus* in primary (1/4") and secondary (3/4") trawl stations in North Carolina during October and November, 1980 and March-July, 1981. N=northern area, C-central area, S=southern area. Addition of 1/4" mesh tail bag to the 3/4" trawl is denoted by "//".

winter/early spring and then move from shallow tributaries into bays and sounds during summer and early fall. The larger blue crabs recruit into a commercial pot and trawl fishery that occurs in Pamlico Sound and its tributaries. Tagging studies by Judy and Dudley (1970) indicated that the North Carolina commercial fishery in any estuary depended on the numbers of crabs that reached maturity within each system. Commercial size crabs (greater than 125 mm) were present in estuarine tributaries beginning in April and were increasing in frequency through July.

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PROJECT II

INSHORE PARALICHTHID FLOUNDER TAGGING

by

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and

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ABSTRACT

Of 495 southern flounder (*Paralichthys lethostigma*) tagged in the Pamlico River near Washington, N.C. during Fall 1980, 169 (34.1%) were recaptured. Most of the recoveries were short term ($\leq$ 40 days), most (89.3%) occurred within 6.4 km of the release site, and most (152 or 89.9%) were taken in gill nets. Twelve fish were recovered in the southeastern portion of Pamlico Sound and northern Core Sound. One other fish was recaptured near the North Carolina/ South Carolina border and another was taken off Winyah Bay, S.C., indicating some flounder migrate considerable distances. Six short range, long term (104-219 days) returns indicate some fish overwinter in the river or return there the following spring. Although the exploitation rate over about 10 months was 34.1%, this must be considered an overestimate because the tags tended to tangle in gill nets, making tagged fish more vulnerable than untagged fish to that gear. Fifteen (9.4%) of 158 southern flounder tagged in lower Core and Back Sounds in October and November 1980 were recaptured - all but two within 45 days and 6.4 km of the release site. The remaining two recoveries were made off eastern Florida in February and July. Of 311 *P. lethostigma* tagged in the Neuse River in April 1981, 110 (35.4%) were recaptured. Through July 1981, 106 (96.4%) of the recaptures had occurred within 11.3 km of the release site, indicating very limited movement. Two long range recaptures were made - one about 50 km downstream in Core Creek and the other about 70 km downstream off Beaufort Inlet. Gill nets accounted for most (101 or 91.8%) of the recaptures in the Neuse River. Sixty-seven summer flounder (*Paralichthys dentatus*) were tagged from Cape Lookout to Beaufort Inlet in June and July 1981. Only one fish was recaptured, and it was taken two days after release in the release area.

INTRODUCTION

Paralichthid flounders, particularly summer flounder, *Paralichthys dentatus*, and southern flounder, *P. lethostigma*, are very important commercial and recreational species in North Carolina. Commercial landings of flounder, comprised primarily of *P. dentatus* taken in the offshore winter trawl fishery and, to a much lesser extent, *P. lethostigma* taken in the inshore pound net fishery (Wolff 1977, DeVries 1981), have ranged from 5.4 to 7.7 million kg worth 2.84-7.95 million dollars annually from 1974 through 1980[1] (U.S. Dept. of Commerce 1977, 1978, 1980). In total value, flounder has been the leading food-fish landed in North Carolina since at least 1965, and in 6 out of the last 10 years, it has ranked second only to shrimp among all North Carolina fisheries, including menhaden (Street 1981).

In order to effectively manage and maintain these valuable flounder fisheries, the sources, locations, movements and numbers of stocks involved must be determined. Several tagging studies have been conducted on *P. dentatus* to answer these questions (Westman 1946, Poole 1962, Murawski 1970), including a two year program conducted on the offshore overwintering grounds off North Carolina by the Division of Marine Fisheries. Despite these studies, questions still remain, especially concerning the contribution of Pamlico Sound juveniles to the offshore stocks. Poole (1966) suggested that Pamlico Sound may serve as a major nursery area for summer flounder. Published tagging work on *P. lethostigma* has been limited to a single Texas study (Stokes 1977) in the Aransas Bay area.

The objectives of this study were to determine the movements, number, and distribution of stocks of southern and summer flounder in the estuarine waters of North Carolina, particularly Pamlico and Core Sounds and their tributaries.

METHODS

Flounder were captured primarily by gill net and a 26 ft wing trawl, with a few taken by other trawls and hook and line. Most of the tagging occurred in

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[1]Landings data from 1977 through 1980 are preliminary and subject to revision in the Fishery Statistics of the United States.

in three general areas during two time periods: upper Pamlico River just below Washington, N.C. and lower Core Sound/Back Sound during October and November 1980 and upper Neuse River just below New Bern, N.C. in early April 1981 (see Figure 6 for locations). Gill nets were used during the fall of 1980 and the wing trawl in April 1981. A small number of flounder were tagged throughout the Pamlico Sound system whenever they were captured during other Division sampling. In addition, *P. dentatus* were captured in late June and July 1981 at Cape Lookout Bight and along Shackleford Banks using hook and line.

Fish were tagged above the lateral line over the pectoral fin or along the posterior dorsal edge of the body with a 19 mm diameter Petersen disc attached with a nickel pin. All specimens were measured to the nearest mm total length (TL) at the time of tagging. Rewards of 1, 5, 10, and 25 dollars were randomly assigned to individual tags before tagging started. The project was publicized by placing posters at fish houses and other public places where fishermen might gather.

Distances traveled by recaptured fish were computed as the most direct, straight-line route by water.

RESULTS AND DISCUSSION

A total of 1,001 southern flounder were tagged in North Carolina estuaries during October 1980 - July 1981; 299 (29.9%) were recaptured during that period. Because of the difficulty in obtaining large numbers of summer flounder, only 73 were tagged, and only 1 was recaptured through July 1981. Most of the southern flounder (962) were tagged in three widely separated locations over relatively short periods of time (11-45 days), and results from each release area will be discussed separately.

Pamlico River, September-November 1980

A total of 495 southern flounder 252-503 mm TL (Figure 1a) were tagged and released in the Pamlico River 6.4 km (4 mi) east of Washington, N.C. during the period 23 September - 6 November 1980. One hundred sixty-nine (34.1%) ranging from 275 to 467 mm TL (Figure 1a) were recaptured. Most of the recoveries were short term; 72 occurred within 0-10 days, 81 within 11-40 days, 5 within 41-70 days, and 11 within 71-219 days.

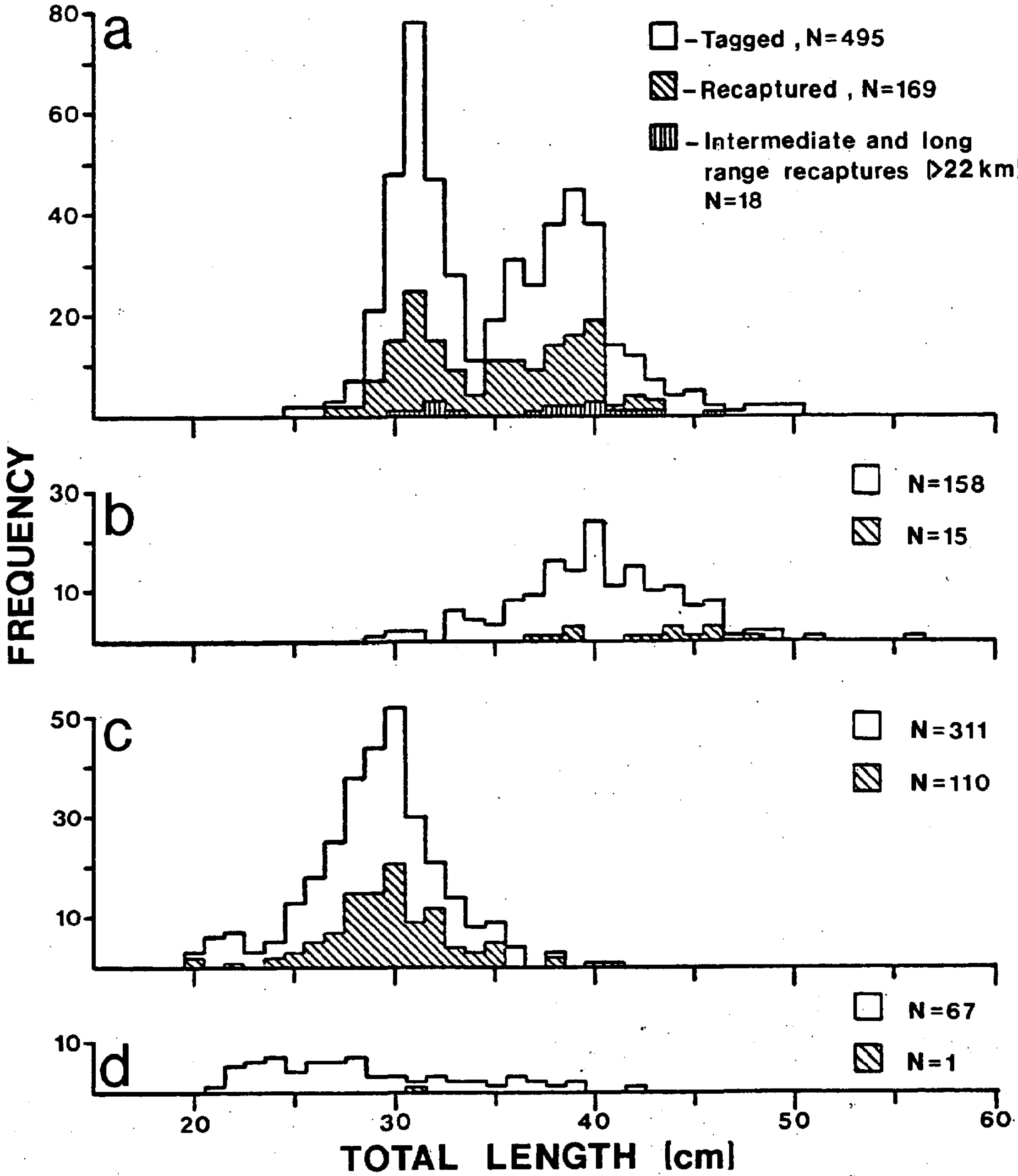

Figure 1. Length frequencies of southern flounder tagged in a) Pamlico River 23 Sep - 6 Nov 1980, b) southern Core and Back sounds 3 Oct - 10 Nov 1980, and c) Neuse River 3-13 Apr 1981, and summer flounder tagged d) between Cape Lookout Bight and Beaufort Inlet 25 Jun and 9, 10 Jul 1981.

Most of the recaptures (89.3%) occurred within 6.4 km (4 mi) of the release site. These short range recaptures included 141 (92.9%) of the 151 fish caught within 40 days, 2 of the 5 taken within 41-70 days, and most notably, 8 of the 11 recovered within 71-219 days (Figures 2-5). Four recaptures were made at intermediate ranges 22.5 - 30.6 km (14-19 mi) downstream of the release site, three at Mixon's Creek 9,11, and 16 days after release and one near the mouth of South Creek 119 days after release (Figures 2, 3, and 5).

Fourteen long range (84-386 km) recaptures were made and these are detailed in Table 1. Ten of the 14 were caught in the southeastern corner of Pamlico Sound off Cedar Island and in northern Core Sound, and two were caught near Ocracoke Inlet (Figure 6); these 12 fish were at liberty an average of 31 days. The remaining two long range recoveries were made in the Intercoastal Waterway (IWW) near the North Carolina-South Carolina border 184 days after release and off Winyah Bay, S. C. 111 days after release.

Gill nets were responsible for 152 (89.9%) of the recaptures. Of the remaining 17 returns, one was found dead, two were taken by hook and line, and seven each were caught by trawl and pound net. The 152 gill net recaptures were all made in the Pamlico River, where the total number of returns was only 155. This very high proportion of returns from gill nets reflects the rather intense flounder gill net fishery located around the release site and the pronounced tendency of Petersen disc tags to become tangled in gill nets. The seven pound net recoveries represented all the returns from Core Sound and the one from Portsmouth Island, areas which both have an extensive flounder pound net fishery. The four returns from the Cedar Island Beach area were all taken in shrimp trawls.

The large number of short term (0-40 days), short range ($\leq$6.4 km) returns provides little information on movements, but mainly reflects the intense gill net fishery which was operating in the tagging area and the tendency of the tags to entangle the fish in those nets. The significant number of short range returns (81, 47.9%) taken 11-40 days after release suggests that at least some of the tagged fish, if not the population in general, remain in the area for at least a few weeks. The low number of recaptures within 41-70 days (7) and 71-103 days (2) may reflect, in part, a sharp drop in effort during the winter

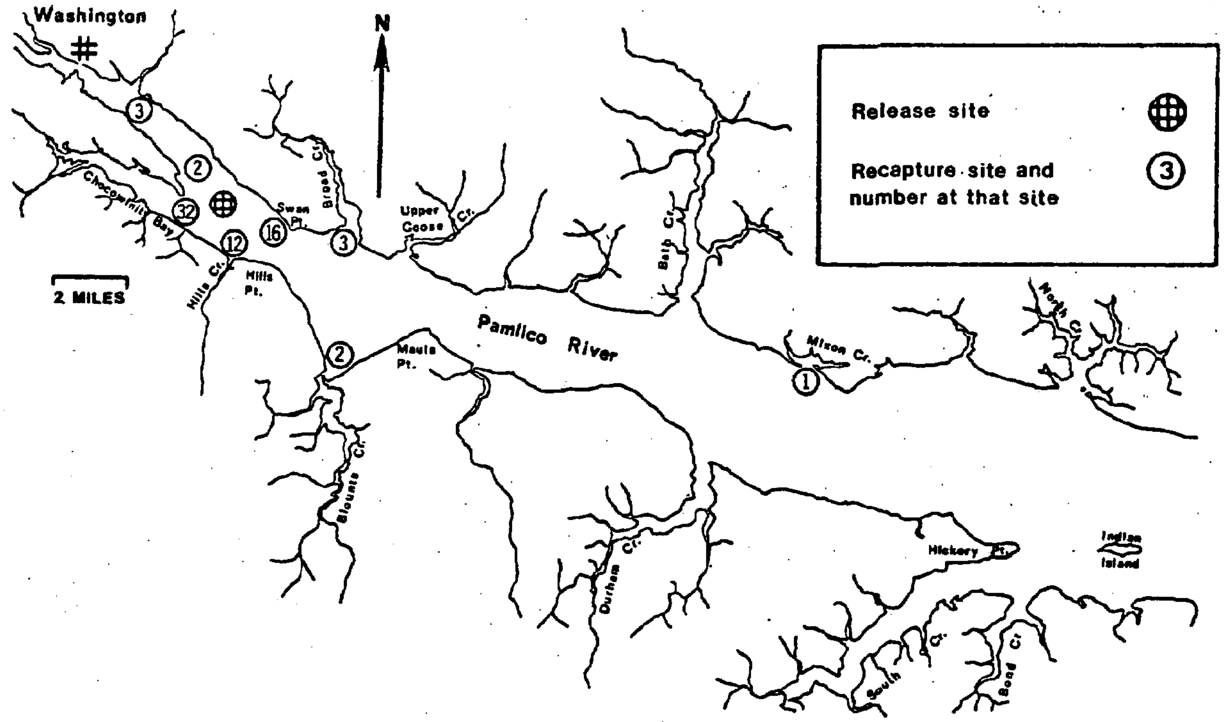

Figure 2. Recaptures within 0-10 days of release of southern flounder tagged in the Pamlico River 23 Sep - 6 Nov 1980. See Figure 6 for long range recaptures.

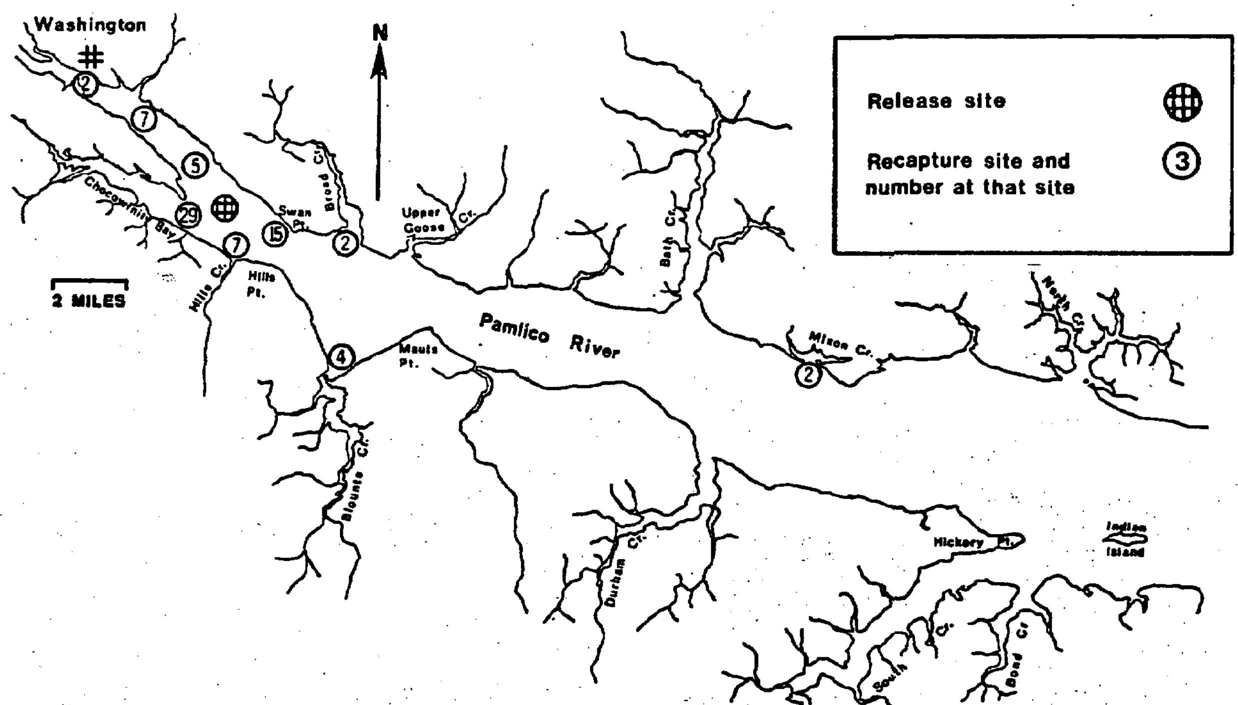

Figure 3. Recaptures within 11-40 days of release of southern flounder tagged in the Pamlico River 23 Sep - 6 Nov 1980. See Figure 6 for long range recaptures.

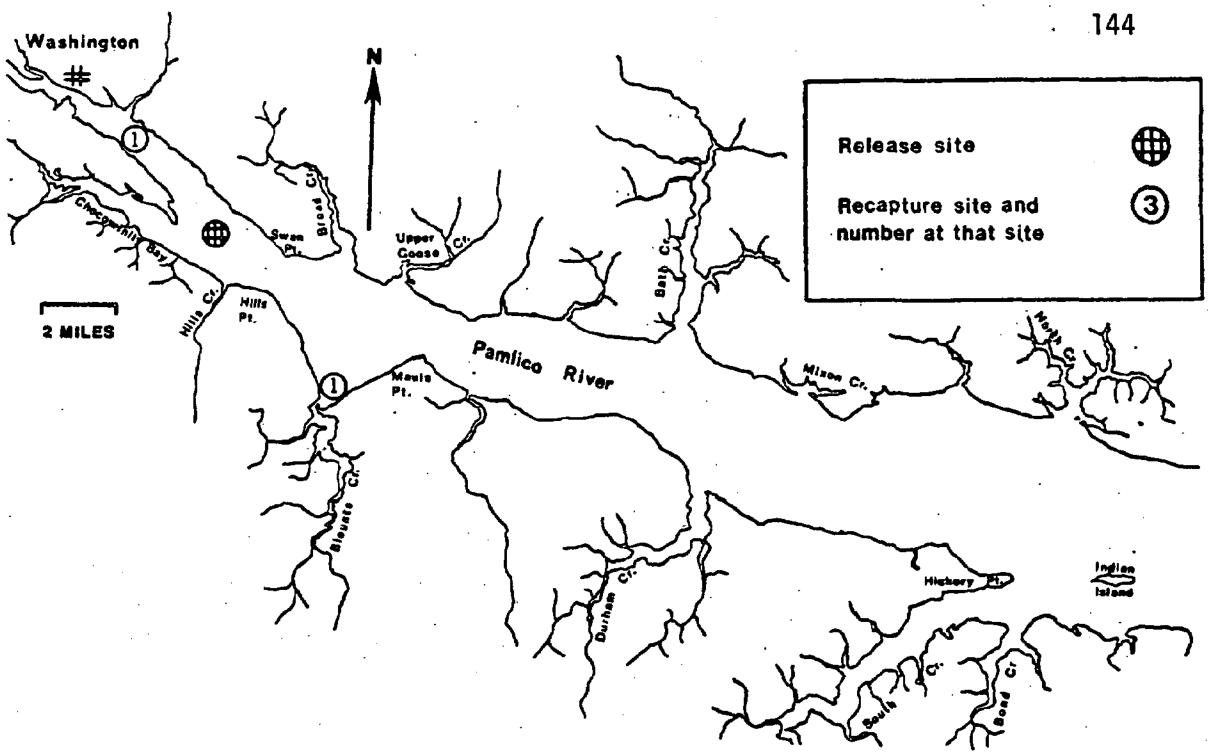

Figure 4. Recaptures within 41-70 days of release of southern flounder tagged in the Pamlico River 23 Sep - 6 Nov 1980. See Figure 6 for long range recaptures.

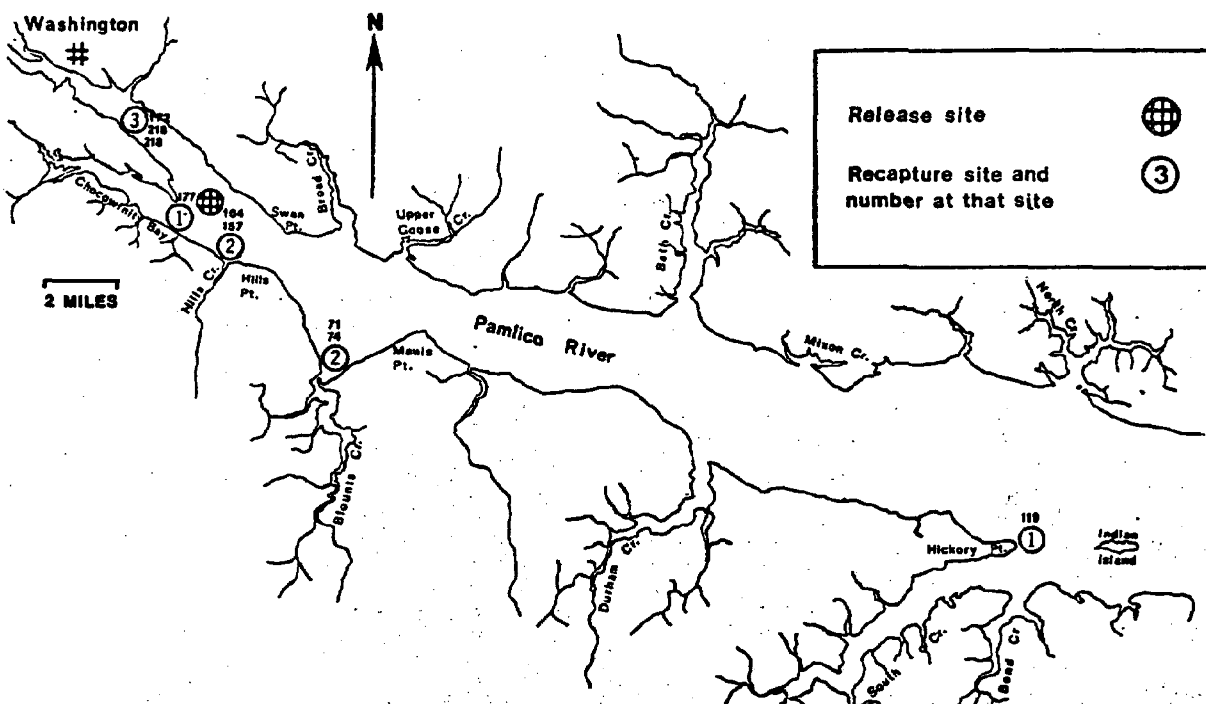

Figure 5. Recaptures within 71-219 days of release of southern flounder tagged in the Pamlico River 23 Sep - 6 Nov 1980. The numbers outside the circles indicate the days at liberty for those fish. See Table 1 for long range recaptures.

Table 1. Long range recaptures of southern flounder tagged in the Pamlico River just below Washington, N.C., 23 September - 6 November 1980.

Tagged		Recaptured				
Date	TL(mm)	Date	Location	Gear	Km/Mi traveled	Days out
30 Sep 80	435	30 Oct 80	Mouth of Thorofare Bay, Core Sound	Pound net	97/60	30
1 Oct 80	302	6 Nov 80	Northern Core Sound near Marker #13	Pound net	92/57	36
2 Oct 80	314	12 Nov 80[1]	Chain Shot Island, northern Core Sound	Pound net	89/55	41
2 Oct 80	406	20 Nov 80	Near Wainwright Island, northern Core Sound	Pound net	89/55	49
3 Oct 80	410	25 Oct 80	Northern Core Sound, 5 mi. NE of Atlantic, NC	Pound net	92/57	22
3 Oct 80	467	28 Oct 80	Off Cedar Island Beach southeastern Pamlico Sound	Shrimp trawl	84/52	25
3 Oct 80	382	30 Oct 80	Off Cedar Island Beach, southeastern Pamlico Sound	Shrimp trawl	84/52	27
3 Oct 80	390	31 Oct 80	3½ mi. off Cedar Island Beach, southeastern Pamlico Sound	Shrimp trawl	84/52	28
3 Oct 80	372	4 Apr 81	Near marker #99, IWW near Ocean Isle, NC	Hook & line	322/200	184
8 Oct 80	406	12 Nov 80	Banks side of Core Sound, south of Drum Inlet	Pound net	109/68	35
10 Oct 80	422	18 Oct 80	Near Portsmouth Island at Ocracoke Inlet	Pound net	92/57	8
14 Oct 80	328	28 Oct 80	Off Cedar Island Beach, southeastern Pamlico Sound	Shrimp trawl	84/52	14
14 Oct 80	323	4 Dec 80	4 mi. E. of Ocracoke Inlet, Atlantic Ocean	Fish trawl	101/63	54
28 Oct 80	390	16 Feb 81	3 mi. N. of Winyah Bay, S.C., Atlantic Ocean	Shrimp trawl	386/240	111

[1]Approximate recapture date.

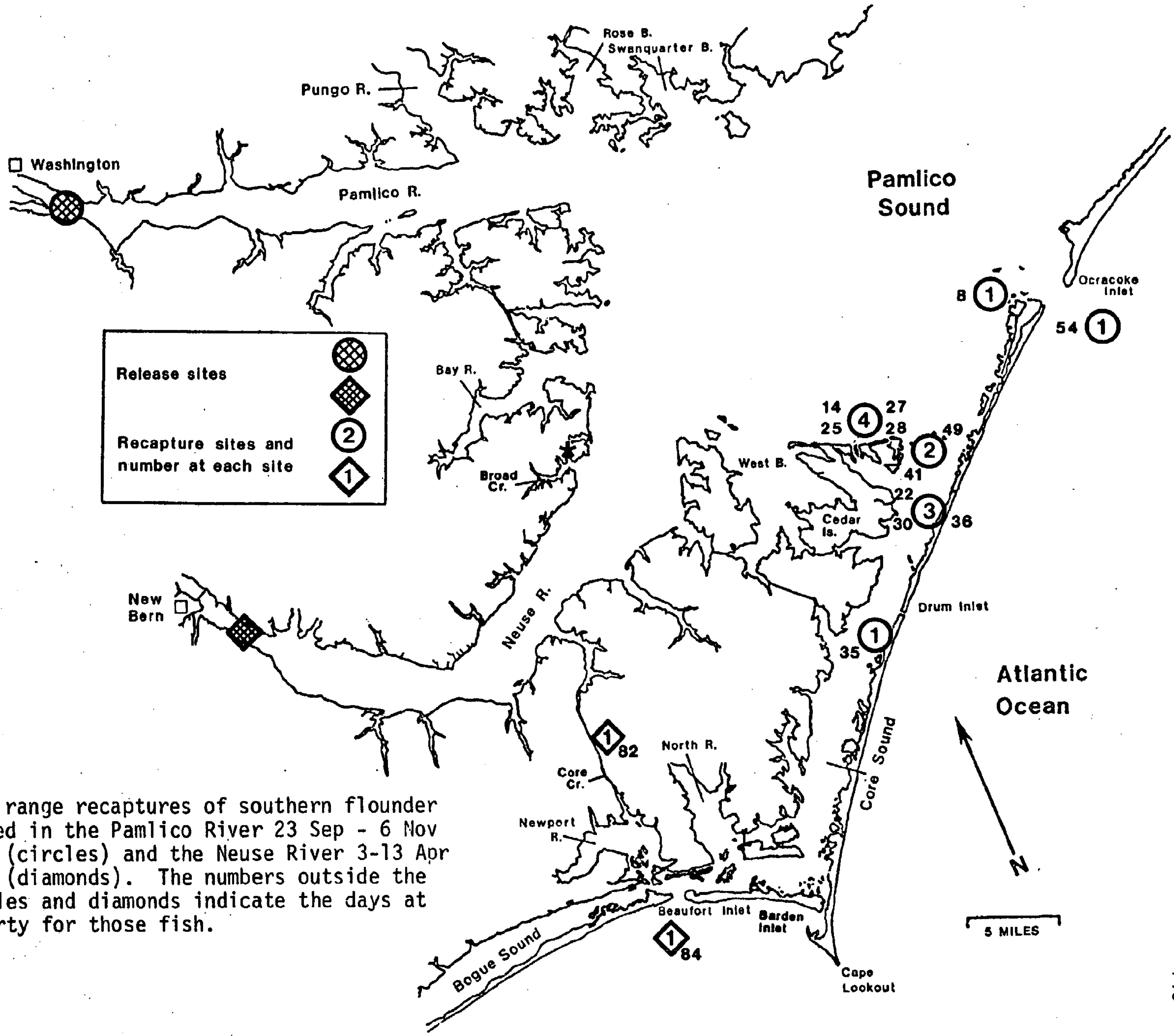

Figure 6. Long range recaptures of southern flounder tagged in the Pamlico River 23 Sep - 6 Nov 1980 (circles) and the Neuse River 3-13 Apr 1981 (diamonds). The numbers outside the circles and diamonds indicate the days at liberty for those fish.

months. Six of the short range returns were taken 104-219 days after release (Figure 5), indicating that some flounder either remain in the upper Pamlico River through the winter or return there the following spring or summer.

The intermediate and long range returns ($\geq$22.5 km) indicate a downstream movement, primarily to and into Core Sound (Figure 6), presumably enroute to the ocean via Drum, Barden, and Beaufort Inlets. The two returns from near Ocracoke Inlet, one from four miles offshore, indicate at least some southern flounder utilize that inlet as well. Most of the fish recovered in or near Core Sound had traveled an average of 2-3 km (1-2 mi) per day, assuming straight line courses, although one fish averaged 11.5 km (7.1 mi) per day.

Some southern flounder apparently migrate considerable distances, as evidenced by the two longest range returns - one from the IWW near the North Carolina/South Carolina border and one from the Atlantic Ocean off Winyah Bay, S. C. (Table 1). The fish recaptured in the IWW traveled a minimum of 322 km (200 mi) in 184 days, while the fish from off Winyah Bay traveled a minimum of 386 km (240 mi) in 111 days.

These long distance movements are not unprecendented. Stokes (1977) reported that a southern flounder tagged at Port Aransas, Texas was recaptured in the Gulf of Mexico in 36 fathoms of water 451 km (280 mi) northeast of the tagging site. Tagging studies of the closely related summer flounder (Marawski 1970, unpublished N.C. Div. of Marine Fisheries data demonstrated movements of at least 386-483 km (240-300 mi) in the Atlantic Ocean.

Analysis of the length frequency of the 18 intermediate and long range ($\geq$22.5 km) recaptures suggests that a much higher proportion of age II or older flounder than age I fish migrate to the ocean in the fall. The length frequency of all fish tagged (Figure 1a) shows two distinct modes which probably represent mainly age I and II fish, based on ageing data from DeVries (1981). However, age II or older fish comprised twice as much of the intermediate and long range recaptures as did age I fish (Figure 1a). When the short range ($\leq$6.4 km) recaptures are included in the length frequency (Figure 1a), the proportion of age I and II or older fish is similar.

The exploitation rate of these fish while in the Pamlico River for the period of 23 September 1980 - 31 July 1981 was 31.1%. This figure must be considered an overestimate, given the tendency of the Petersen disc to easily tangle in gill nets (Murawski 1970, Ricker 1975). Exploitation rate here is defined as the number of recaptured tagged fish/total number of fish tagged (Ricker 1975). Although nonreporting of recaptures and tagging mortality would have resulted in underestimates of exploitation, the tendency to tangle in gill nets was almost certainly a more important factor in recapture rates, considering the very high (89.9%) rate of gill net recaptures.

Only 1.4% of the Pamlico River fish were recaptured in the fall pound net fishery from OCracoke to Beaufort Inlet, but this figure is probably an underestimate of the true harvest rate for the following reasons. First, because of the tendency of the tags to tangle in gill nets, a greater proportion of tagged than untagged fish were caught while in the river, so conversely, a lower proportion of tagged than untagged fish were able to migrate from there. Second, an unknown proportion of flounder apparently overwinter in the upper river, so that some of the tagged fish, even if they were not caught in a gill net, were probably not exposed to the pound net fishery. Finally, nonreporting of recaptures almost always occurs to some unknown extent.

Core and Back Sounds, October-November 1980

One hundred fifty-eight southern flounder 290 to 562 mm TL (Figure 1b) and one summer flounder were tagged and released in lower Core and southern Back sounds from 3 October to 10 November 1980. Of these, 15 (9.4%) fish ranging from 378 to 473 mm TL were recaptured - 10 in ≤14 days, 3 in 23-45 days, 1 in 131 days, and 1 in 275 days. Thirteen (86.7%) were captured within 6.4 km (4 mi) of their release site (Figure 7). Three flounder moved towards Beaufort Inlet and three to or through Barden Inlet. Only one fish moved north - a fish tagged in southern Back Sound was recaptured three days later in the Straits north of Harkers Island about 9 km (6 mi) from the release site (Figure 7). Two long distance recaptures were made. One fish was recaptured in February (131 days at liberty) 4.8 km (3 mi) off of the mouth of the St. John's River, Fla., a straight line distance of about 645 km (400 mi) and an average movement of 4.9 km (3.1 mi)/day. Another flounder was recaptured 275 days after release (31 July 1981) by hook and line at Ponce de Leon Inlet, Fla., a distance of about 740 km (460 mi).

Of the 15 returns, 6 were taken by gill net, 4 by hook and line, 2 by gig, 1 by pound net, 1 by trawl, and 1 unknown. Two of the gill net recaptures were made in our project gear.

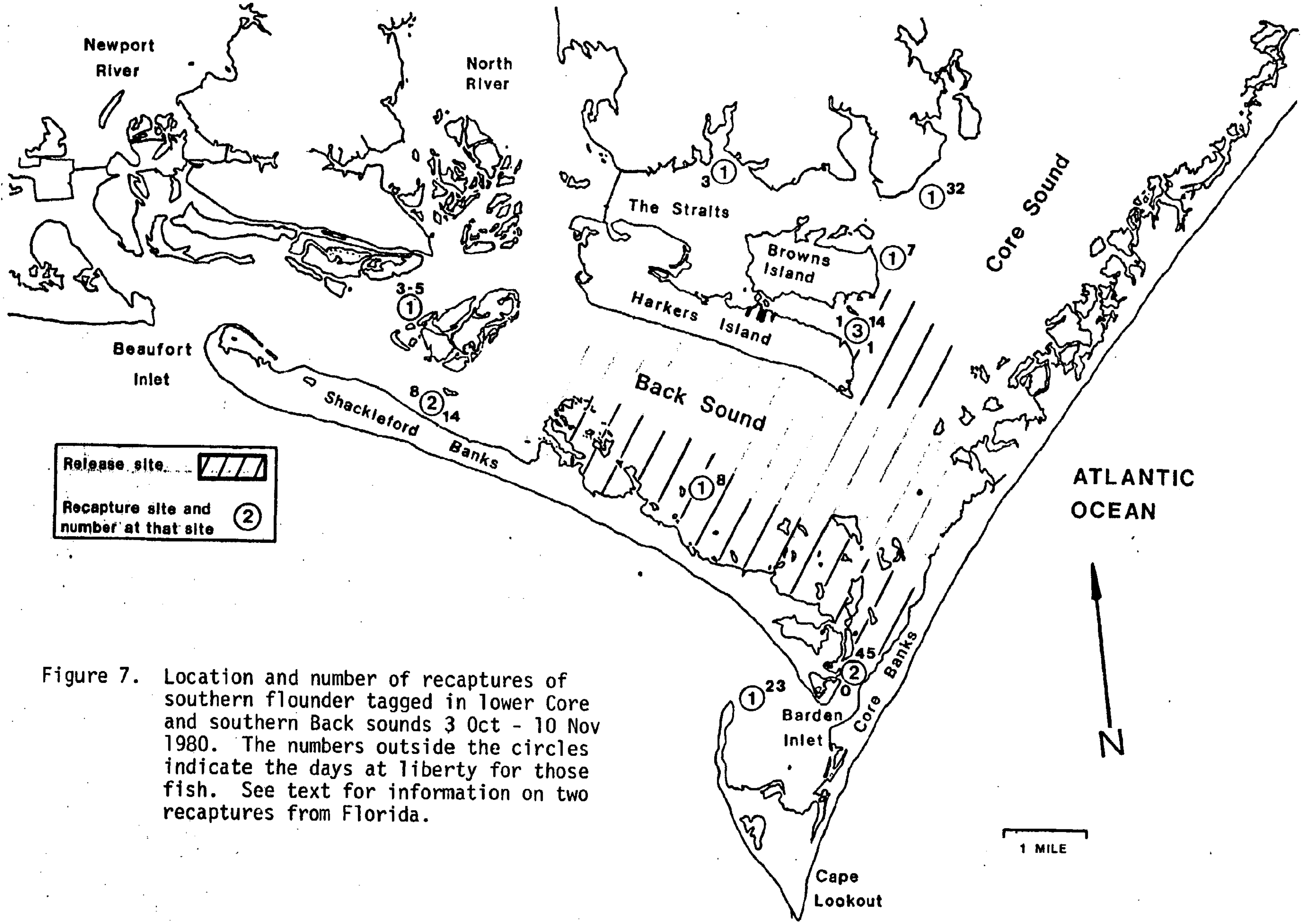

Figure 7. Location and number of recaptures of southern flounder tagged in lower Core and southern Back sounds 3 Oct - 10 Nov 1980. The numbers outside the circles indicate the days at liberty for those fish. See text for information on two recaptures from Florida.

The low number of returns for these flounder probably resulted from the fish being tagged during their spawning migration to the ocean and close to Beaufort and Barden Inlets, so their availability to capture, especially by gill nets, was limited compared to fish tagged in Pamlico and Neuse rivers. The two recoveries from Florida, which are the longest distance returns to date, may also partly explain the lack of returns, in that they provide additional evidence that some southern flounder leave North Carolina waters and travel considerable distances southward. It is unknown if these fish ever return to North Carolina.

Neuse River, 3-13 April 1981

A total of 311 *P. lethostigma* were tagged in the Neuse River just below New Bern, N.C. between Johnson and Fort Points, 3-13 April 1981 (Figure 8). The tagged fish ranged from 200 to 414 mm TL (Figure 1c) so most were probably age II (DeVries 1981). One hundred ten (35.4%) of these flounder ranging from 200 to 414 mm TL (Figure 1c) were recaptured through July 1981 - 47 (42.7%) within 0-10 days, 16 (14.5%) within 11-40 days, 30 (27.3%) within 41-70 days[2], and 17 (15.5%) within 71-113 days (Figures 8-11). As in the Pamlico River, gill nets accounted for most (101 or 91.8%) of the recaptures, with 1 fish taken by trawl, 1 by crab pot, 1 by gig, and 7 by unknown means.

Through July 1981, all but four of the recaptured fish exhibited only very limited movement; 106 (96.4%) were recaptured within 11.3 km (7 mi) of the release site. Of the 4 other returns, one was taken 8-12.9 km (5-8 mi) downstream of the release site, and about 6.4 km (4 mi) west of Slocum Creek (Figure 9); one 16.1-20.9 km (10-13 mi) downstream, 1.6 km (1 mi) east of Slocum Creek (Figure 11); one 49.9-54.7 km (31-34 mi) downstream at the Core Creek Bridge (Figure 6); and one 69.2-74.0 km (43-46 mi) from the release site, off Beaufort Inlet (Figure 6). The fartherest upstream recoveries were two taken 1.6 km (1 mi) north of the Highway 17 Bridge and 4.8-11.3 km (3-7 mi) from the release area. No fish were recovered from the Trent River.

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[2]Eleven tags were returned without specific recapture dates, only a time period which equated to a possible range of 42-83 days at liberty. All of these fish are included in Figure 10.

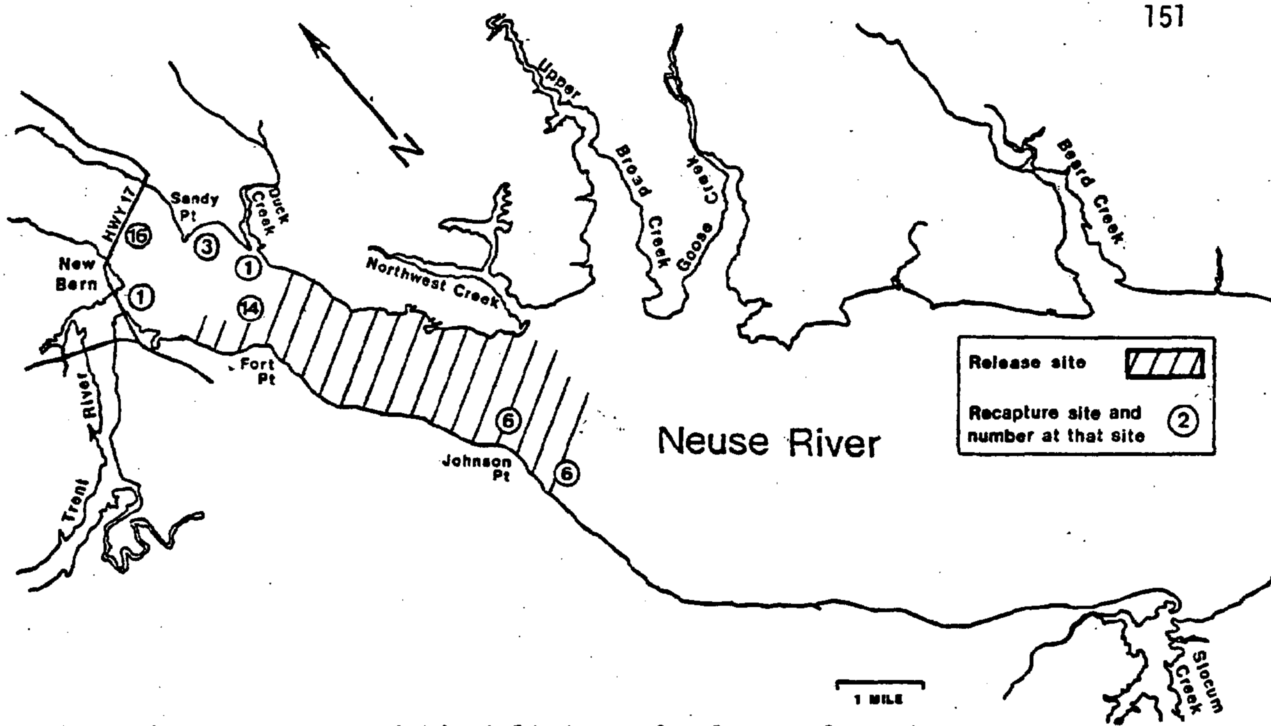

Figure 8. Recaptures within 0-10 days of release of southern flounder tagged in the Neuse River 3-13 Apr 1981.

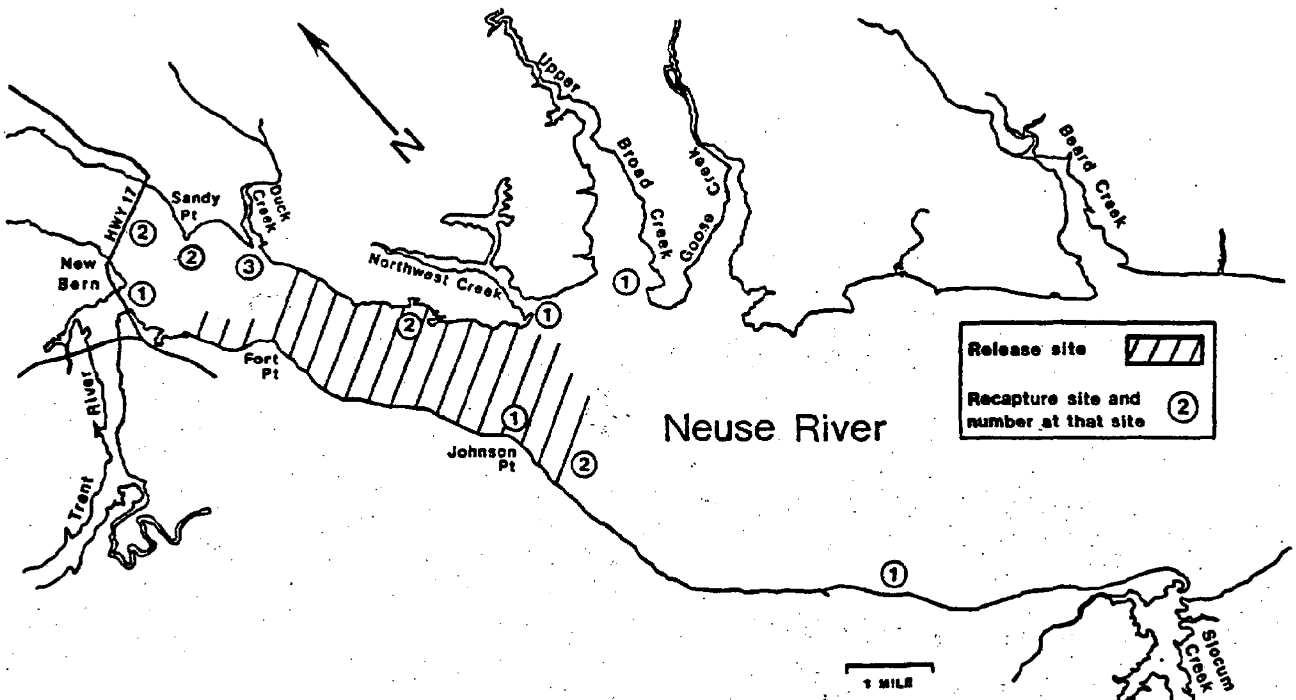

Figure 9. Recaptures within 11-40 days of release of southern flounder tagged in the Neuse River 3-13 Apr 1981.

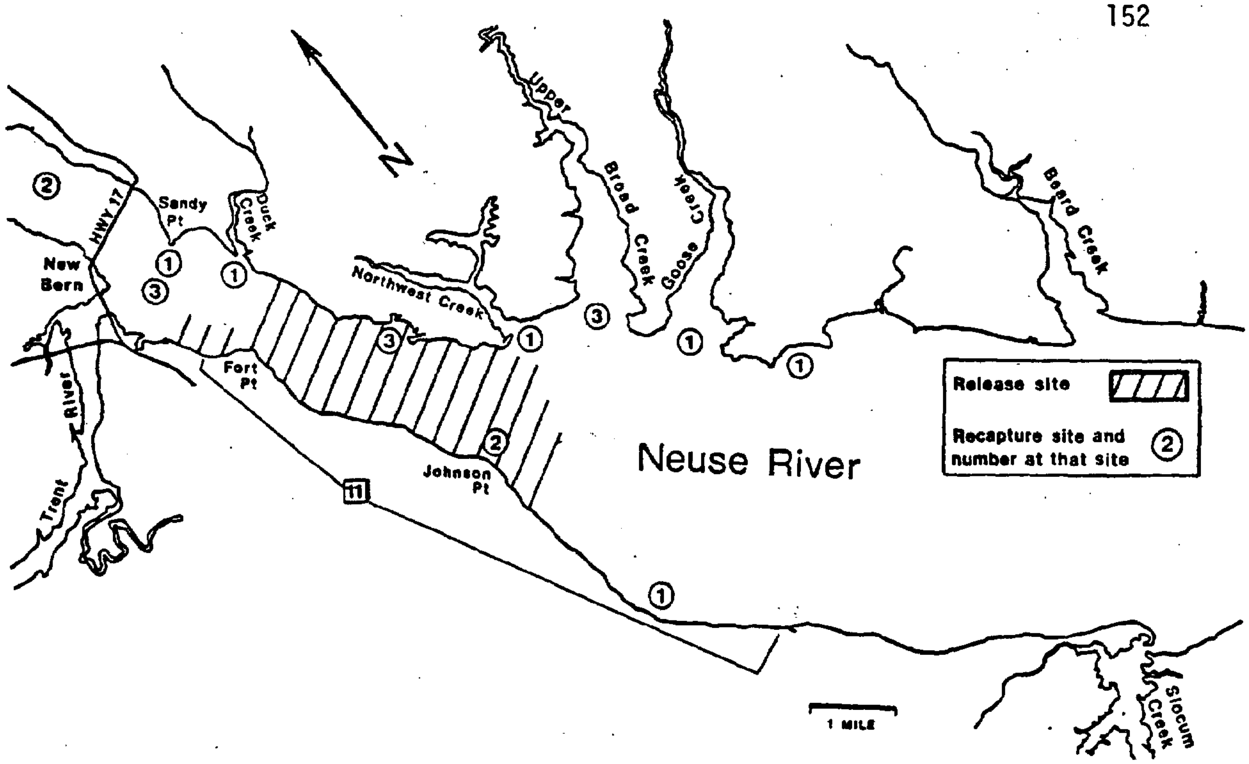

Figure 10. Recaptures within 41-70 days of release of southern flounder tagged in the Neuse River 3-13 Apr 1981. The number within the square refers to a group of fish recaptured in the area indicated by the brackets sometime between 42 and 83 days after release.

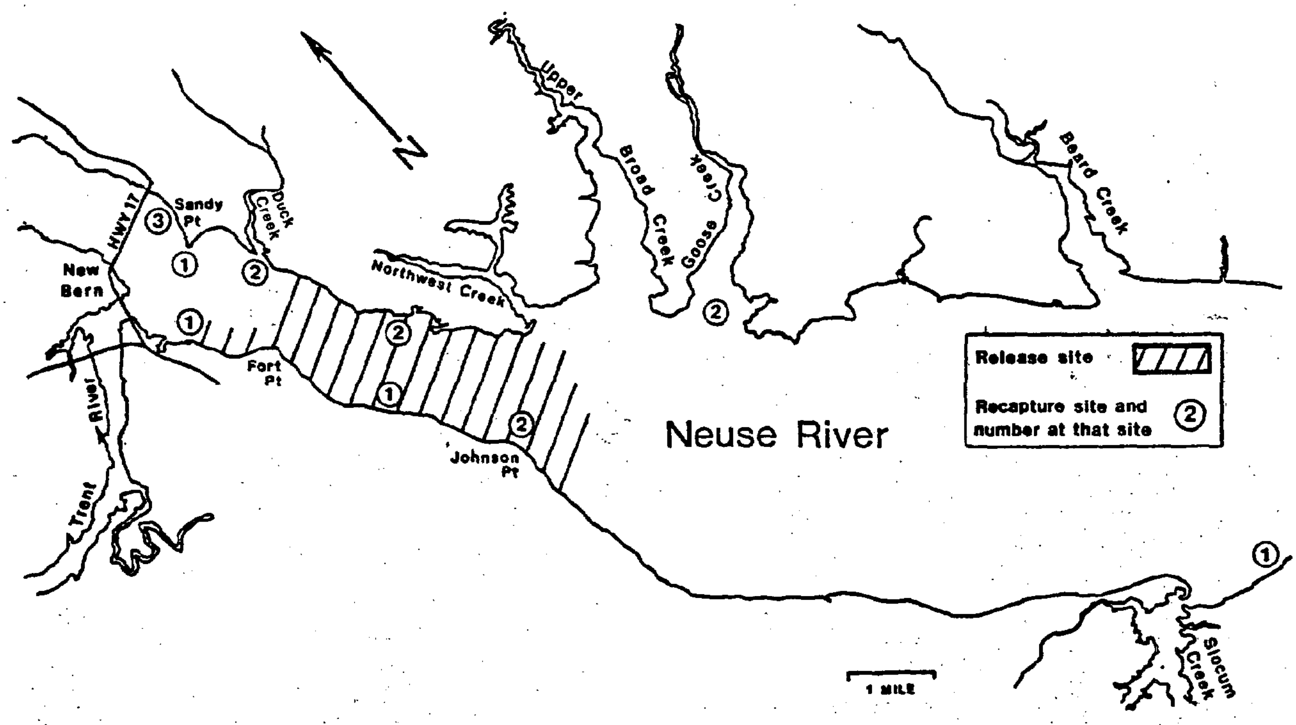

Figure 11. Recaptures within 71-113 days of release of southern flounder tagged in the Neuse River 3-13 Apr 1981. See Figure 6 for additional long range recaptures.

The very large proportion of short range ($\leq$11.3 km) returns indicates that most of the southern flounder tagged in the Neuse River spent the spring and summer months there. The lack of recoveries from very far upstream or the Trent River suggests that the Neuse River just below the Highway 17 Bridge at New Bern may be the normal upstream limit of distribution for the species. Keup and Bayless (1964) noted that *P. lethostigma*, although occasionally found in freshwater in the Neuse River, were most common in salinities above 1.75 ppt. During the tagging bottom salinities in the release area were about 3 ppt. Another likely reason for the lack of upstream and Trent River recaptures is the lack of effort directed towards flounder in these areas, which are traditionally fished for fresh or anadromous species.

The recaptures made in Core Creek and off Beaufort Inlet, both in early July, suggest that some flounder move to or towards the ocean in the summer, four or five months before the peak fall spawning migration.

The exploitation rate of the Neuse River fish from April through July 1981 was 35.6% but this is probably an overestimate for the same reason given for the Pamlico River fish, i.e. tangling of tags in gill nets.

Miscellaneous Locations, November 1980-July 1981

Twenty-five southern flounder 192-318 mm TL were tagged in several locations in southern and western Pamlico and northern Carteret counties, November 1980-July 1981. These fish were tagged during the course of other Division sampling when tags were available. Only one of these fish was recaptured - a fish released in a tributary of Broad Creek (star in Figure 6) in southern Pamlico County on 22 June 1981 was recaptured 22 days later in Broad Creek about 2 km from the release site.

In addition 13 southern flounder 313-343 mm TL were tagged on 14 and 17 April 1981 in the upper Pamlico River in the same area where the fish were tagged the previous fall. Four of these fish were recaptured, all in gill nets, 2-3 km upstream after 8, 19, 21, and 26 days. These few returns show the same pattern seen with the Neuse River fish tagged in April.

Cape Lookout - Beaufort Inlet, June-July 1981

Sixty-seven summer flounder 210-421 mm TL were tagged and released from Cape Lookout to Beaufort Inlet on 25 June and 9 and 10 July 1981. Only one fish was recaptured through July 1981 and it was caught by hook and line two days after release in the release area.

RECOMMENDATIONS

1. Continue tagging for at least two more years and attempt to tag much greater numbers of both southern and summer flounder to better define movements and exploitation rates by various gears and hopefully provide mortality rate data with second and third year returns.
2. Tag southern flounder in Albemarle Sound to determine their migration routes.
3. Tag flounder off Cedar Island Beach to determine the exploitation rate in the Core Sound pound net fishery.
4. Use pound net for tagging in Core Sound in the fall to increase the numbers tagged there.
5. Convince other states to tag southern flounder off northeast Florida, South Carolina, and Georgia to see if any northward migration occurs.
6. Determine feasibility of using a non-tangling tag in the Neuse and Pamlico rivers to get better estimates of exploitation.
7. Determine sex ratio and its relationship to size of flounder in the tagging areas at the time of tagging.

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PROJECT III

WESTERN ALBEMARLE SOUND NON-ANADROMOUS FISHERIES

by

Robert C. Harriss, Jr.

ABSTRACT

The size and age composition of the Albemarle Sound commercial harvest of white perch, channel catfish and white catfish was examined. White perch from age groups three through eight were present during the 1979-80 season,with age groups four and five dominating the samples. The situation was similar during 1980-81. Channel catfish from age groups two through nine were present, with age groups three, four, and seven dominating the harvest. White catfish from age groups three through seven were present, with age groups three and four dominating the samples.

INTRODUCTION

The commercial fisheries of the Albemarle Sound area have been historically dependent upon the harvest of anadromous fishes during their spring migrations to and from the spawning grounds. Due to the seasonality of the anadromous fish harvest, area fishermen and dealers have become increasingly interested in the harvest of nonanadromous species. The commercially significant nonanadromous species are white catfish (*Ictalurus catus*), channel catfish (*Ictalurus punctatus*), white perch (*Morone americana*), American eel (*Anquilla rostrata*), southern flounder (*Paralichthys lethostigma*), and blue crab (*Callinectas sapidus*). The landings for white perch and both species of catfish combined in the Albemarle Sound area compared with the entire state's landings during the period from 1976 to 1981 are shown in Table 1 .

Catfish landings in the Albemarle Sound area averaged approximately 1,620,000 pounds over the five year period beginning in 1976. Landings peaked in 1977, and have declined slightly each year since. The Albemarle Sound area produces approximately 90% of the total catfish harvest in the state.

White perch landings peaked in 1978. The Albemarle Sound area accounted for approximately 85% of the total North Carolina harvest during 1976-80. Since 1978,white perch landings have generally declined.

The purpose of this study was to obtain data necessary to develop and implement improved management of white perch and catfish in the Albemarle Sound area. Past work objectives of this study were to investigate the relative abundance of juvenile white perch and catfish in the Chowan River, determine time and areas of white perch spawning in the Chowan River, examine the age and size composition of the commercial harvest of white perch and catfish, and conduct a tagging study on white perch.

Due to termination in federal funding for project 2-372-R, field work was abandoned after February 1981. It should be noted that due to loss of funding, only one-half of the adult harvest data was collected for 1980-81, and no catfish tagging programs or juvenile assessment programs were undertaken.

Table 1. North Carolina and Albemarle Sound area landings for catfish and white perch for 1976-1981 (Published and unpublished data, Division of Marine Fisheries and NMFS, Beaufort, N.C.)

Species	Year	North Carolina landings (lb.)	Albemarle Sound area landings (lb.)	Percent Albemarle Sound area landings
Catfish	1976	1,538,124	1,480,200	96.2
	1977	2,073,100	2,043,600	98.6
	1978	1,713,102	1,687,774	98.5
	1979	1,651,600	1,495,100	90.5
	1980	1,625,739	1,402,770	86.3
Jan - July	1981	1,524,795	1,306,061	92.0
White perch	1976	183,625	175,800	95.7
	1977	268,200	257,700	96.1
	1978	687,414	482,619	70.2
	1979	361,032	320,800	88.9
	1980	104,803	80,625	76.9
Jan - July	1981	268,177	238,252	88.8

METHODS

Adult Harvest Survey

During 1978-80, Keefe and Harriss (1981) sampled three sites in the Albemarle Sound area monthly to determine the age and size composition of the commercial harvest of the principal nonanadromous species (Figure 1). Collectively, these sites best represent the commercial harvest in the area.

Beginning in October 1980, length frequencies of white perch and catfish were taken monthly at the same three sites, with spines (catfish) and scales (white perch) taken semi-annually (in the spring and fall) for age determination. Due to reduction of federal funding for Project 2-372-R, all Albemarle Sound area field work was discontinued after February 1981. The report, therefore, only considers information obtained from October 1980 through February 1981.

Sample size depended on the number of specimens and the size range present at the individual locations; all specimens were measured (FL) to the nearest millimeter and weighed to the nearest 0.01kg. Sex information was obtained for white perch during the spawning season when gonadal material could be squeezed from the abdomen.

Scale samples were obtained from white perch in the area between the dorsal fins and above the lateral line. Approximately one dozen scales were obtained from each white perch sampled. Scales were placed in coin envelopes and allowed to dry. Approximately six scales were mounted and impressions were made on acetate slides by means of a roller press. Scale impressions were viewed under a binocular dissecting microscope with a micrometer eyepiece. Annuli were counted to determine age according to the criteria set forth by Mansueti (1961).

The left pectoral spine was removed from white and channel catfish. When the left pectoral spine was broken or damaged, the right spine was removed. Pectoral spines were removed by clipping the joint with wire cutters, then pulling the spine outward and rotating it until free. Spines were prepared according to the method described by Sneed (1950). Spines were sectioned by making two cuts with a hobby saw approximately 1mm apart. Spine sections were immersed in a watchglass containing glycerine and viewed under reflected light with a binocular dissecting microscope. Winter zones were counted to determine the age of the catfish.

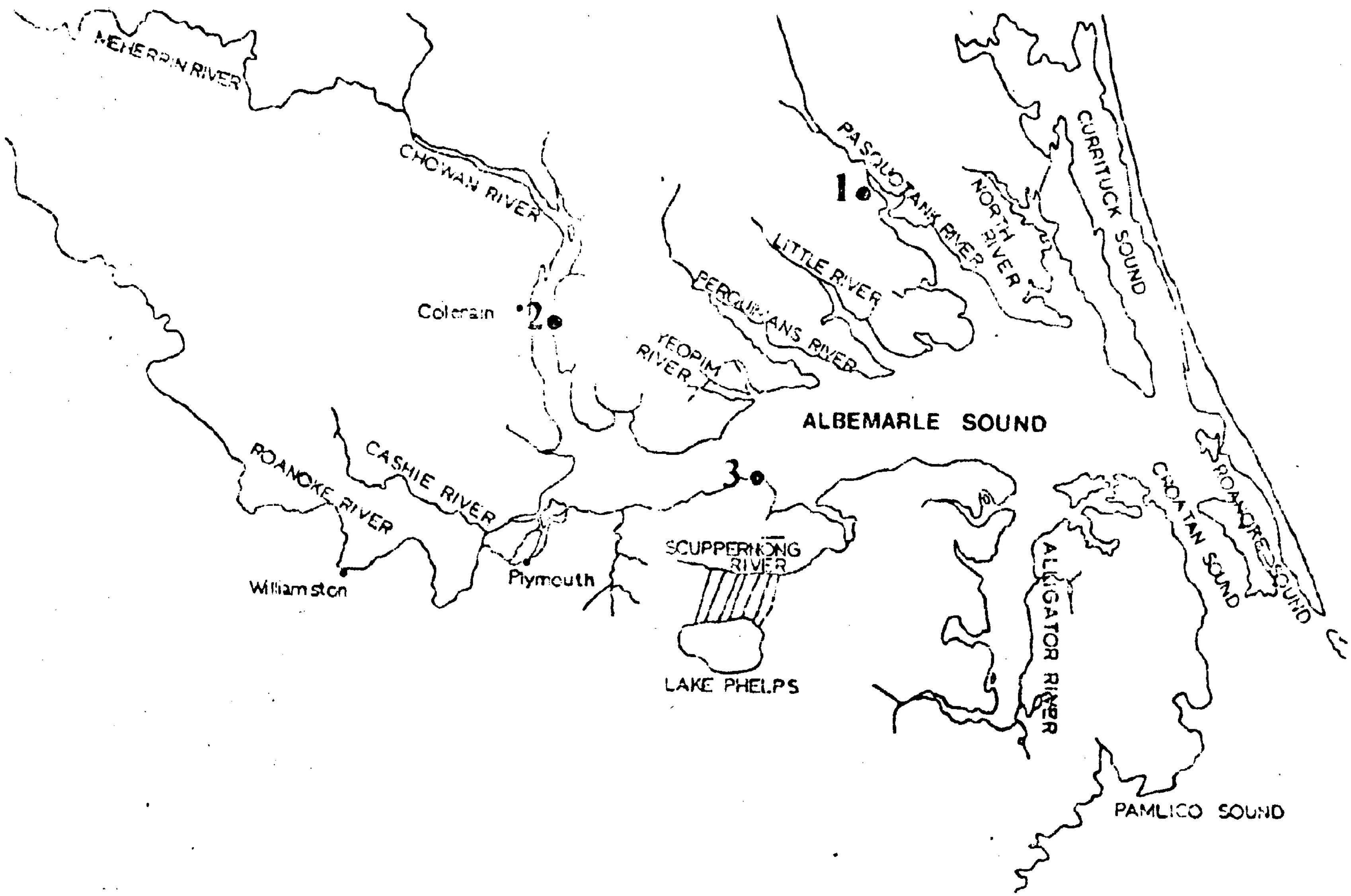

Figure 1. Sampling sites for adult harvest survey of nonanadromous species in the Albemarle Sound area, 1980-81.

RESULTS AND DISCUSSION

White Perch

Because of the timing of termination of funding and the planned sampling schedule, a total of only 88 white perch were sampled for age. Number, mean fork length and weight, and standard deviations for each age group of white perch, sexes combined, sampled from the Albemarle Sound commercial harvest during 1980-81 are presented in Table 2. During 1980-81, white perch from ages three through eight were present in samples. White perch of ages four and five accounted for 52% of the harvest. These figures correspond closely with those of the adult harvest for the previous two years (Keefe and Harriss 1981). The fish generally tended to be longer and heavier than during 1979-1980 (Keefe and Harriss 1981).

The length frequency distribution for white perch in 10 mm size groups are presented in Figure 2. White perch ranged in fork length from 180 to 290 mm and were dominated by those occurring in the 231-240 size range. The mean fork length at age three was 221 and at age eight the mean was 249.

A total of 121 white perch were examined from the commercial catch to determine sex ratios. The sex ratio was 3.03:1 (females to males) as compared to 2.58:1 and 2.39:1 in the past (Keefe and Harriss 1981). Females dominated all age groups. The departure from the expected 1:1 sex ratio probably is due to the selectivity of commercial gear for faster growing females, as noted by Keefe and Harriss.

Catfish

Catfish are commercially harvested in the Albemarle Sound area by pound nets, gill nets, fyke nets, trot lines, haul seines, and fish pots. It was assumed that sampling in the fish houses obtained catfish from all gears used commercially. No attempt was made to analyze the data separately for each gear.

A total of 373 catfish were sampled for length frequency, of which 125 were found suitable for age determination. Forty-five of these were channel catfish, while 80 were white catfish.

Number, mean length and weight, and standard deviation for each age group of channel catfish are shown in Table 3. Channel catfish, sampled from the

Table 2. Number, mean length and weight, and standard deviations by age for white perch, sexes combined, sampled from Albemarle Sound, N.C. commercial harvest during 1980-81.

Age	Number	% of sample	Fork length (mm) mean	Fork length (mm) SD	Weight (kg) mean	Weight (kg) SD
III	15	17	221	12.9	0.21	0.033
IV	28	32	229	13.8	0.23	0.044
V	18	20	239	23.7	0.32	0.25
VI	15	17	255	19.4	0.32	0.92
VII	8	9	263	11.2	0.37	0.066
VIII	4	5	249	23.3	0.29	0.069
	88					

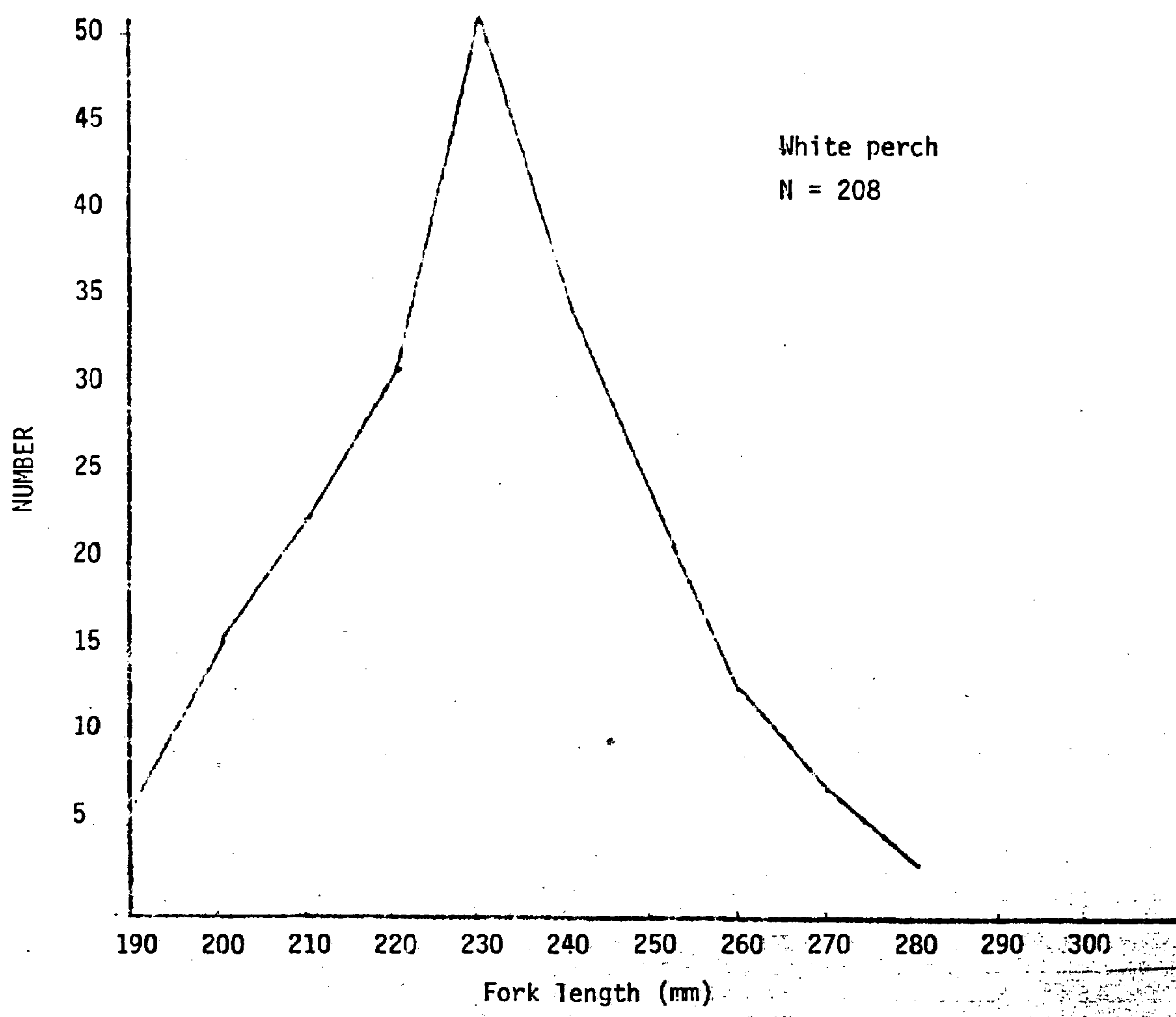

Figure 2. Length frequency distribution for white perch, sexes combined, sampled from the Albemarle Sound commercial harvest during 1980-81.

Table 3. Number, mean length and weight, and standard deviations by age for channel catfish, sexes combined, sampled from the Albemarle Sound, N.C. commercial harvest during 1980-81.

Age	Number	% of sample	Fork length (mm) mean	Fork length (mm) SD	Weight (kg) mean	Weight (kg) SD
II	5	11	225	40.8	0.15	0.069
III	9	20	284	76.1	0.34	0.32
IV	8	18	309	111.2	0.55	0.84
V	3	7	393	30.6	0.78	0.25
VI	7	16	410	96.0	1.16	0.75
VII	10	22	457	122.8	1.56	1.26
VIII	2	4	572	104.7	2.63	1.56
IX	1	2	622		3.39	
	45					

commercial catch, ranged from age two to nine, and age group seven was the most abundant.

Number, mean length, weight, and standard deviations for each age group of white catfish are presented in Table 4. From the data collected,it appears that white catfish do not live as long or grow as large as channel catfish (Keefe and Harriss 1981). White catfish from age groups three to seven were present, and age groups three and four were the most abundant in the commercial harvest. White catfish from age groups three and four accounted for 79% of the fish sampled.

The length frequency distribution for channel and white catfish in 10mm size groups are presented in Figures 3 and 4, respectively. Channel catfish ranged in fork length from 190 to 750mm, and were weakly dominated by those occuring in the 210-239mm and 400-429mm size classes. White catfish ranged from 179mm to 490mm FL and were dominated by those in modal groups between 240mm and 339mm.

As discussed by Keefe and Harriss (1981), enlargement of the lumen was observed in most of the pectoral spines examined from both species of catfish. The lumen increased at the expense of adjacent bony material obliterating the first and sometimes two or three annuli. Generally, one annulus was added to both channel and white catfish if the lumen radius was greater than 10 units and the distance to the first visible annulus was greater than 18 units.

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Special thanks are extended to Jackie Davis and Margaret Stafford for typing the report.

Table 4. Number, mean length and weight, and standard deviations by age for white catfish, sexes combined, sampled from the Albemarle Sound, N.C. commercial harvest during 1980-81.

Age	Number	% of sample	Fork length (mm) mean	Fork length (mm) SD	Weight (kg) mean	Weight (kg) SD
III	35	44	261	46.5	0.31	0.16
IV	28	35	328	52.8	0.62	0.33
V	10	13	341	45.8	0.71	0.38
VI	5	6	410	68.0	1.17	0.47
VII	2	2	408	36.1	1.18	0.24
	80					

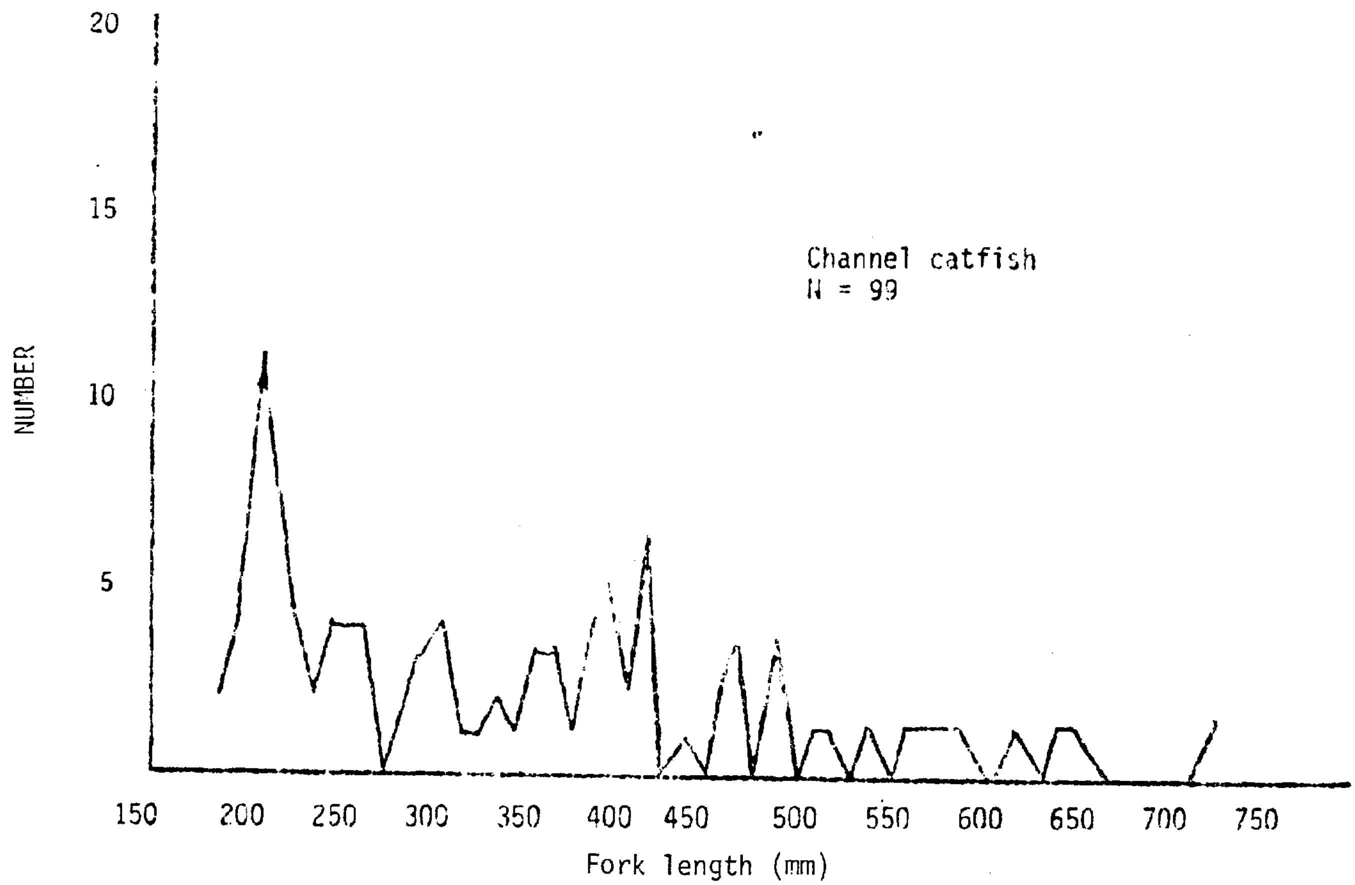

Figure 3. Length frequency distribution for channel catfish, sexes combined, sampled from the Albemarle Sound commercial harvest during 1980-81.

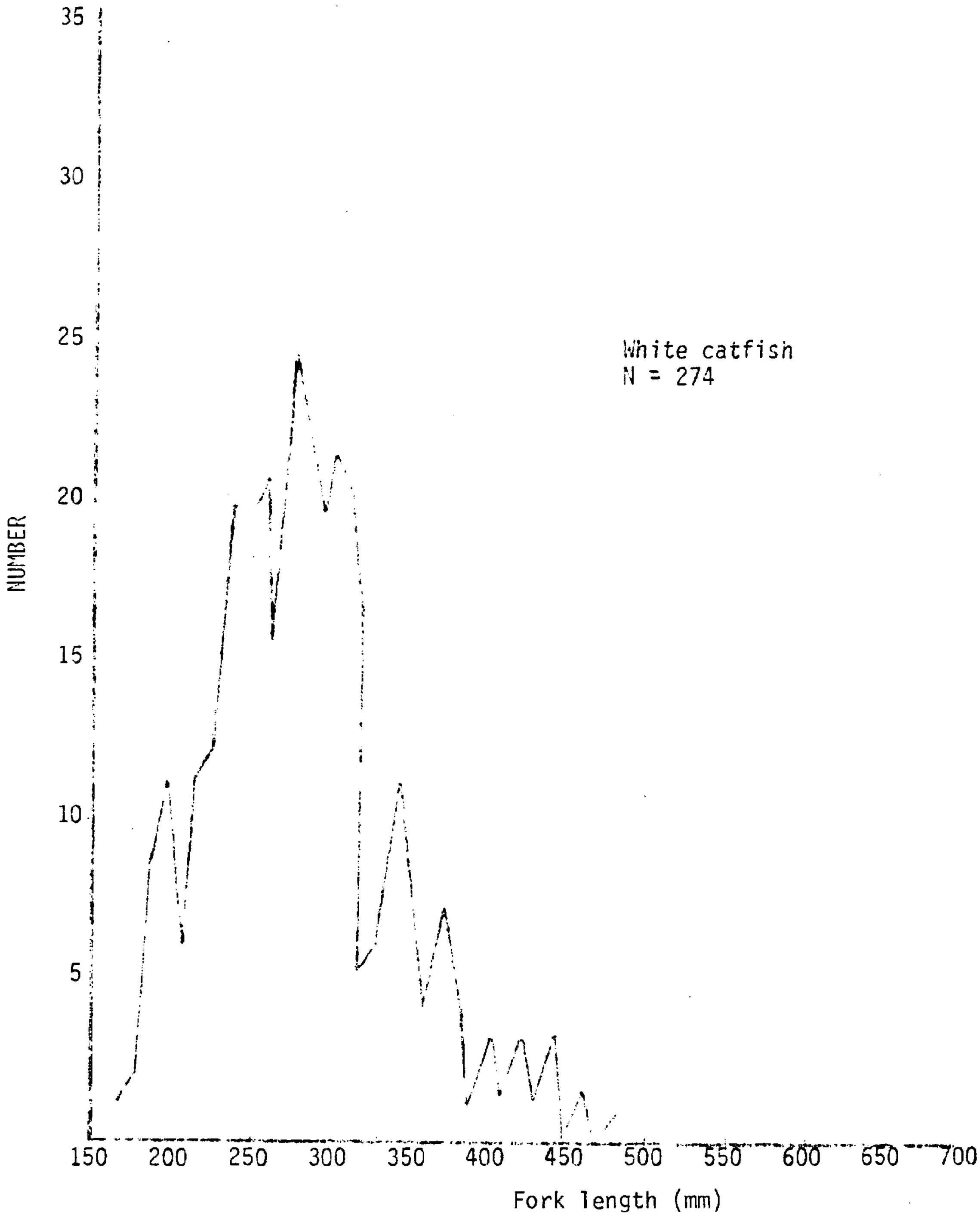

Figure 4. Length frequency distribution for white catfish, sexes combined, from the Albemarle Sound commercial harvest during 1980-81.

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